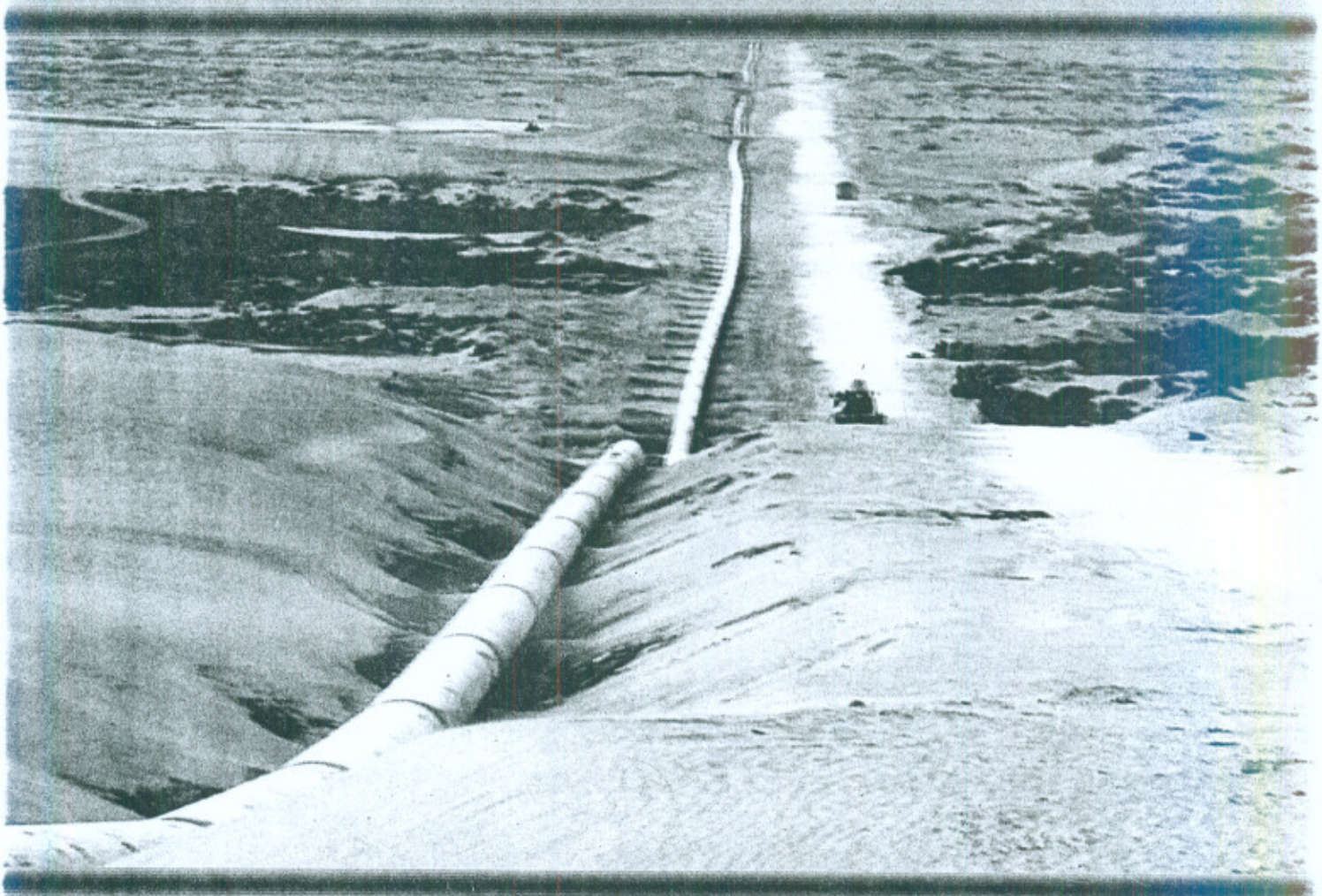
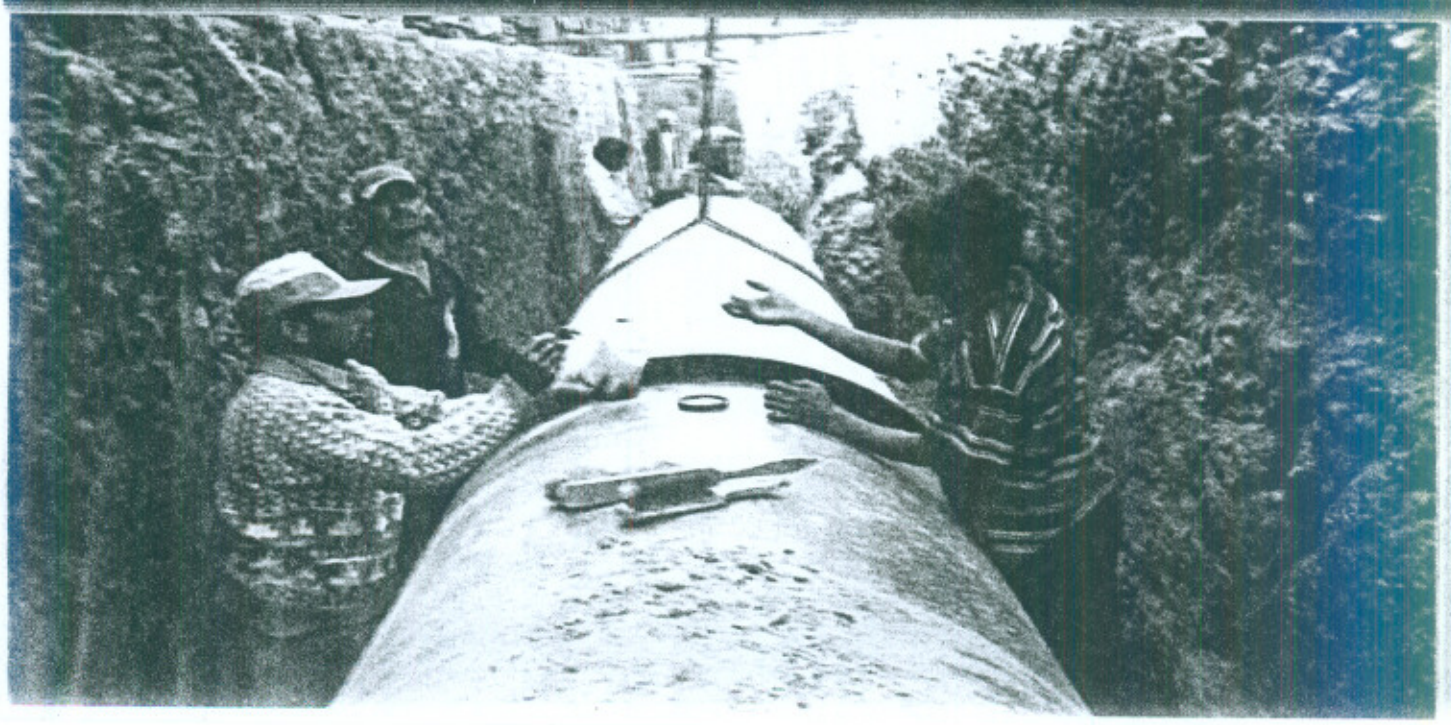
Engineering News

A Quarterly Journal of the Pakistan Engineering Congress

Vol: 42 April - June 2005 No: 5





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Top: Hofuf Water Supply Project in Saudi Arabia

Bottom: Sewerage Pumping Main in Lahore

47th YEAR OF PUBLICATION

Engineering News

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PUBLISHED BY
Pakistan Engineering Congress
Ph: 042-5784237-5784238
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EDITORIAL

WORLD ENVIRONMENT DAY

WORLD ENVIRONMENT DAY has also been observed on 5th June 2005 in PAKISTAN like other countries around the GLOBE, with the Theme of GREEN CITIES – PLAN FOR THE PLANET. It is important for all of us to understand the objectives of this Theme in view of ever-increasing demands of the population. The cities are expanding in a haphazard manner regardless of simultaneous expansion of utilities resulting into environmental degradation. It is high time that we should contribute in an organized manner for proper planning, design, execution, operation and maintenance of projects. It is mandatory under Law of the Land that environmental impact studies must be carried out for the proposed development projects. Presently, NEW MURREE HILL RESORT is a hot issue from environmental point of view. It is encouraging to note that concerned Environmental Protection Agencies are now serious on this issue. Recently, Ministry of Environment has constituted committees to prepare draft National Water and Sanitation Policies to achieve Millennium Development Goals for sustainable development to the maximum possible extent. For this purpose, individuals, groups, civil society and politicians have to work together to achieve the objectives leading to better environment.

NEWS

Seminar on "World Environment Day"

* Pakistan Engineering Congress organized a seminar to celebrate World Environment Day on 5 June 2005 at Lahore. Seminar was inaugurated by Makhdoom Ashfaq Ahmad, Minister for Environment, Government of Punjab. Following is the text of Address of Welcome given by Engr. Muhammad Saeed Ahmad Khan, President of the Pakistan Engineering Congress:

Quote

It is my pleasure to welcome you all to this gathering for cermonizing "World Environment Day". I also have to thank the respected Chief Guest and all of you for finding some time to attend this event of global importance.

Environment protection and conservation development Programme in Pakistan draws its inspiration from Stockholm convention of 1972 held under the aegis of United Nations. An Environment Protection Ordinance was enacted in 1983 as a starting point followed by National Conservation Strategy (NCS) in 1992. And the enactment of "Pakistan Protection Environment Act 1997" was a milestone specifying the National Environmental Quality Control Standards as a bench mark. Then a strategy was formulated by the Government of National Environmental Action Plan in 2001 in order to redress the aggravating environmental degradation. It could not achieve desired results due to lack of enforcement with the writ of the Government. This strategy had main focus on clean air, clean water, waste management and eco-system management. Despite the continued efforts to correct environmental degradation, the quality of environment in the country continues to deteriorate resulting in pollution, land degradation, the deforestation, water depletion and loss of bio-diversity. Further more environmental challenges facing Pakistan have amplified over the year owing to a number of factors such as high population, prevailing poverty, and unplanned urban and industrial expansion migratory trend from rural to urban and insufficient emphasis on environmental protection in the Government policies.

The theme of "World Environment Day – 2005" is "Green Cities". This global theme addresses the environmental protection requirements in major urban cities which can no longer be viewed in Pakistan as environmentally safe and healthy. Increasing pollution of air, land and water are now matter of concern for every one in urban areas of Pakistan. Rapid changes in environmental conditions due to emissions from vehicular traffic, indiscriminate disposal of municipal and industrial liquid wastes are occurring in our major urban areas affecting the life of the people. This deterioration of the quality of environment has brought the people of the major cities of Pakistan to an awareness that their own health and wellbeing as well as fate of future generation depends on the action taken now to safe guard further degradation of our city environment.

Last year on this day I had drawn attention about the gastroenteritis casualties in Hyderabad due to contaminated water supply resulting due to disposal of untreated effluent both municipal and industrial into water bodies. It seems that no serious action has been taken by the concerned authorities so this slackness has been responsible for epidemic in Jacobabad city and in other urban areas of Sind as reported by the media in the recent past. Over a dozen of people died due to gastroenteritis – a big tragedy, thousands people have been affected and hundreds were hospitalized. Last month such incidents also happened in Kasur and Pattoki in Punjab.

Realizing the deteriorating situation of our environment and to control such incidence of water borne diseases the Government has recently prepared "National Environmental Policy 2005 – 15" to embark on a Programme for improving the living environment in the country. This policy is being implemented from this year.

I do hope with this Programme the conditions of living Environment would soon ameliorate as the approach of this policy will not be limited to pollution control but it will focus on pollution prevention "Green Productivity" like waste minimization, waste exchange, recycling green technology and consumer choice Programme.

The key environmental issues facing our urban areas are due to a number of factors as mentioned earlier. The issues which require special attention for better environment in urban areas are as follows:

1. Fresh Water resources are severely polluted due to discharge of untreated municipal and industrial wastes.
2. Municipal water supplies are not conforming to WHO standards, for drinking water.
3. Air pollution is on the rise especially in major urban areas.
4. Noise pollution is much higher than permissible limit in certain areas of major cities.
5. Solid waste collection and disposal (approximately 54850 tons of wastes in Urban areas), so far no city in Pakistan has foolproof arrangement of 100% collection of solid waste.
6. Degradation and encroachment on city parks and road side plantation.
7. Public awareness of pollution control.
8. Sustainable development to safe guard environment.
9. Community participation for environment issues.

We have assumed here today to remind ourselves about the fast approaching environmental crisis in our major urban areas and the urgency of taking appropriate measures. I do hope that this seminar on World Environment Day will discuss valuable ideas and help in solving urban environmental problems for having "Green Cities" in Pakistan.

At the end, I once again thank you Sir, for sparing your valuable time to inaugurate this Seminar, I am also grateful to the guests for attending the session of the Seminar.

Unquote

* Keynote address on Environmental Legislation and it's Enforcement in Pakistan was delivered by Mr. Anjum Jawaid Khan, Attorney at Law.

* In response, Honorable Minister informed that a national committee under the Chairmanship of Prime Minister is formulating a 10-year national environment policy. He said that the country was facing a threat of environment degradation and 60 per-cent of population had been deprived of clean drinking water. He also informed that the federal government had allocated Rs. 5 billion and the provincial government earmarked Rs. 3 billion for reducing environmental pollution, adding that they would also receive financial grants from the World Bank and the Asian Development Bank for environment protection. "The government is also planning to set up water treatment plants in all big industrial cities of the country" he added.

* Seminar was conducted by Engr. S.M.A. Zaidi, Secretary of the Pakistan Engineering Congress.

* In the Technical Session chaired by Dr. Parvez Hassan, seven speakers participated in the proceedings and gave presentations as under:

- Rao Khalid Mahmood ..... Combating Environment Pollution
  Conservator Forest Punjab — through Afforestation
- Dr. Shagufta Shahjehan..... Green Fund for Clean Cities
  Director Environment Deptt.
  Government of Punjab
- Mr. Shabbir Ahmad..... Environment: Urban Planning & Role of
  Director General PHA — Community
- Engr. Muhammad Shariq Ahmad..... Environmental Impacts of Effluents on
  GT&GE Division NESPAK — Human Health Caused by Waste Water Pollution
- Mr. Ashraf Nadeem..... "Lahore" Air Quality Challenges-Shift
  Health Safety Environment — To CNG
  Department, SNGPL
- Dr. M. Afzal .....Green Cities
  Environment Specialist
- Dr. Muhammad Ashraf.....Diclofenac Toxicity & Vulture Crises
  Dean : Faculty of Bio-Sciences
  Veterinary University

THE WORLD ENVIRONMEN DAY'S THEMES

Year	Themes
1974	Only One Earth
1975	Human Settlements
1976	Water : Vital Source for Life
1977	Ozone Layer Environmental Concern ; Land Loss and Soil Degradation ; Firewood
1978	Development without Destruction
1979	Only one future our Children – Development without destruction
1980	A new challenge for the new decade ; Development without destruction
1981	Ground water ; Toxic chemicals in Human Food Chain and Environment Economics
1982	Ten years after Stockholm (Renewal of Environment Concerns)
1983	Managing and Deposing Hazardous Waste : Acid Rain and Energy
1984	Desertification
1985	Youth Population and Environment
1986	A Tree for peace
1987	Environment and Shelter; More than a Roof
1988	When People put the Environment First, Development will Last
1989	Global Warming ; Global Warning
1990	Children and the Environment
1991	Climate Change ; a need for Global Partnership
1992	Only One Earth, Care and Share
1993	Poverty and the Environment – Breaking the Vicious Circle
1994	One earth One Family
1995	We the People : United for the Global Environment
1996	Our earth, Our Habitat, Our Home
1997	For Life on Earth
1998	For Life on Earth – Save our Seas
1999	Our Earth – Our future – Just Save it!
2000	The Environment Millennium : Time to Act
2001	Connect with the World Wide Web of Life
2002	Give Earth a Chance
2003	Water – Two Billion People are Dying for it!
2004	Wanted Seas and Oceans – Dead or Alive?
2005	Green Cities – Plan for the Planet

WORLD ENVIRONMENT DAY



Left to Right: Engr. Syed Mansoob Ali Zaidi, Mr. Anjum Jawaid Khan,
Honourable Chief Guest Ashfaq Ahmad and Engr. Rana Muhammad Saeed Ahmed Khan



Left to Right: Engr. Syed Mansoob Ali Zaidi,
Mr. Anjum Jawaid Khan, Dr. Parvez Hassan and
Engr. Rana Muhammad Saeed Ahmed Khan



Engr. Ghulam Hussain Vice President,
Pakistan Engg. Congress
(Standing) poses a Question to the Speaker



Mr. Saadat Ali, former Secretary Irrigation & Power Department
Government of the Punjab putting forward his suggestions

FORMER PRESIDENT OF PAKISTAN ENGINEERING CONGRESS HONORARY Ph.D. DEGREE BY UNIVERSITY OF ENGINEERING AND TECHNOLOGY LAHORE



Engr. Ch. Mazhar Ali presently Advisor to Irrigation & Power Department Punjab has been awarded Honorary Degree of Ph.D. by the University of Engineering & Technology Lahore in recognition of his high scholastic record distinguished services towards the promotion of engineering education, profession of engineering and above all untiring nation building activities. Earlier to this, Engr. Ch. Mazhar Ali had been awarded Gold Medal by the Pakistan Engineering Congress on his paper entitled "Structural Investigation of Sukkur Barrage Arches". Heartiest congratulations to Engr. Ch. Mazhar Ali. The Pakistan Engineering Congress in particular and the Engineering Community in general feel proud and elevated and fully share his monumental achievements.

WELCOME TO NEW MEMBERS

The Executive Council of the Pakistan Engineering Congress approved Membership of the following new members in to the Congress fold. The Engineering News congratulates all of them and welcomes them to PEC

Members admitted on 28-05-2005

1 Engr. Tariq Mahmood ul Hassan
2 Engr. Ajaz Ahmad Gondal
3 Engr. Aisha Naheed
4 Engr. Muhammad Ali Riaz
5 Engr. Waheed ur Rehman Sheikh
6 Engr. Adnan Iqbal
7 Engr. Abaid Ullah Khan
8 Engr. Arfan Arshad
9 Engr. Dr. Gurbir Singh Dhillon
10 Engr. Mumtaz Shah
11 Engr. Muhammad Jameel
12 Dr. Syed Muhammad Saeed Shah
13 Engr. Zaheer Ahmed Babar
14 Engr. Mazher Majid
15 Engr. Mehboob Bashir
16 Engr. Muhammad Ashraf
17 Engr. Rizwan Khaliq
18 Engr. Farrukh Saeed
19 Engr. Ahsan Bilal Dar
20 Engr. Arif Ali
21 Engr. Muhammad Arif Irshad
22 Engr. Owais Khan Tariq

ENVIRONMENTAL PROFILE OF LAHORE

By

Engr. M.P. AFTAB*

ABSTRACT

Lahore commands a strategic political and administrative role as the capital of Punjab Province and second largest city of Pakistan with a population of over 6 million. Lahore is situated on a good quality aquifer being main source of potable water supply. Natural nullahs originally for storm water drainage have been encroached upon and become sullage carriers due to inadequate sewerage system. Raw sewage is discharged into River Ravi in the absence of any treatment facility. River Ravi is badly polluted due to indiscriminate discharge of municipal and industrial wastes. No sanitary landfill exists in the city for solid waste management except open dumping. Air quality has also deteriorated in the recent past due to increase in vehicular traffic and inadequate road network. This paper describes existing environmental situation and some proposals for its improvement, which would lead towards sustainable development and poverty reduction in due course.

1) INTRODUCTION TO THE CITY

Lahore is situated in the north eastern part of Pakistan within its centre lying within 25 km of international border with India. It occupies a focal position on the upper Indus Plain and is located along the left bank of River Ravi. Major roads connecting Lahore to other cities are GT Road, Multan Road, Raiwind Road, Ferozepur Road, Sheikhupura Road and Jaranwala Road. The Main Railway line connects Lahore to most of the settlements along northern and southern routes and to the neighbouring country – India, through Wagha in the east [Figure 1].

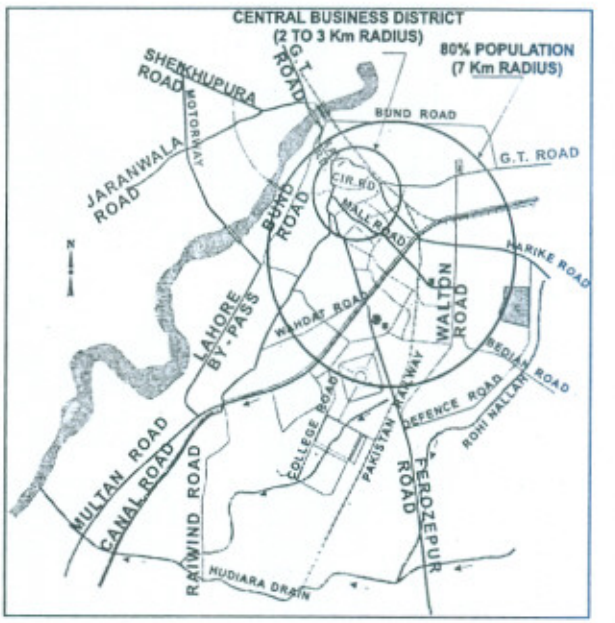


Figure 1 - LAHORE CITY

The general altitude of the area is 208 to 213 m above mean sea level. The area slops towards south and south – west at an average gradient of 1:3000. Lahore can be divided into two parts i.e. the low lying area along River Ravi and the comparatively upland area in the east away from River Ravi. The low lands are generally inundated by the River Ravi water during monsoon floods.

Lahore experiences extremes of climate. In summer season, mean maximum and minimum temperatures vary between 40.4 to 27.4°C. The mean maximum and minimum temperatures in winter are 22 and 5.9 °C respectively [1].

*Vice President, National Engineering Services Pakistan (Pvt.) Ltd (NESPAK)

2) WATER SUPPLY

Water and Sanitation Agency (WASA) of Lahore Development Authority (LDA) is responsible for water supply facility to 84.82% population of Lahore City whereas 10.93% population is served by Lahore Cantt. Board and remaining 4.25% is looked after by others such as Railway, Government of Punjab and various Housing Societies. It is estimated that 4.83 million population resides within the jurisdiction of WASA who have provided 431, 336 number of water supply connections, thus serving 3.28 million which is 70% of the total population.

Main source of water supply 290 Million Gallons per Day (mgd) is ground water abstraction through Tubewells (316) by WASA. Water supply system is designed to provide water at an average rate of 363 litres per capita per day (lpcd) i.e. 80 gallons per capita per day (gpcd). Tubewells are operated for an average duration of 14-16 hours a day. This is the highest figure among the eight Mega cities of Asia including Karachi, Dhaka, Calcutta, Manila, Bangkok, Jakarta, Seoul and Singapore i.e. 120-239 lpcd (26-52 gpcd) and that too for short duration only.

Water quality is normally satisfactory in the WASA service area. There is excessive abstraction of ground water resulting in depletion of water table. Aquifer quality (Total Dissolved Solids) is likely to deteriorate south of Hudiara Drain subject to further hydrogeological investigations. There are 52 overhead reservoirs having a total capacity of 3.16 Million Gallons (MG) and height ranging between 12 to 25m. Only one tank of 1MG at Langey Mandi is in operation for over last 100 years.

3) SEWERAGE

The sewerage system was originally built in the early nineteenth century with the construction of egg-shaped sewers and a sewage pumping station at Main Outfall Road. Since Lahore City is comparatively a flat area and therefore a large quantity of rainwater finds its way into the sewerage system. In fact it is a semi-combined sewerage system.

Existing system in WASA service area caters for about 2.5 million population which is 54.1% of the present population. Sewage is pumped to the storm water cum sullage drains in various sewerage districts and ultimately into River Ravi [Figure 2]. During flood in River Ravi, the gates of storm water drains have to be closed and sullage is pumped across the bund.

Most of the expansion of Lahore City has taken place towards South West during the last one and a half decade. About 250 new housing schemes have come up. The private developers have tried to provide internal infrastructure but no proper sewage disposal facilities are available.

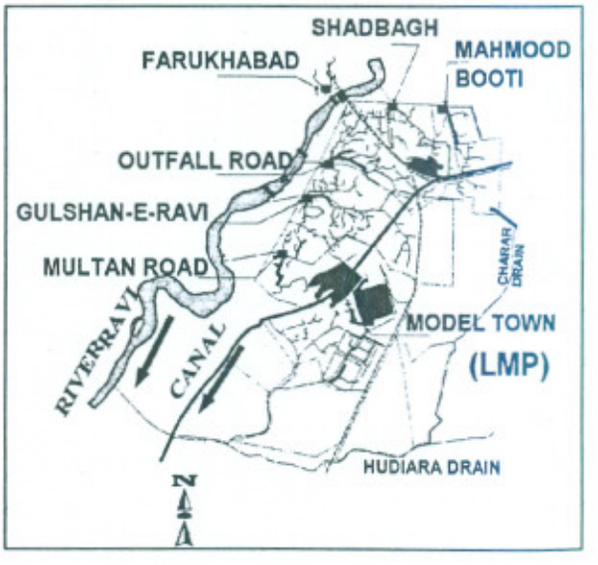


Figure 2 - SEWERAGE SYSTEM

Presently no wastewater treatment facilities exist and raw wastewater is directly discharged into River Ravi thus causing major environmental hazard in the river as well as for the downstream users. The situation becomes extremely critical under low flow condition in the river when sufficient dilution is not

available and the river almost serves as a sullage carrier. Six (6) wastewater treatment plants are required for the city of Lahore.

4) STORM WATER DRAINAGE

Storm water drainage has become a major environmental hazard/civic challenge. The situation becomes worst in the monsoon season which normally extends from July to September. It is not only an issue for the low lying areas but also for the posh areas like Gulberg, Allama Iqbal Town, Garden Town and Model Town. Total length of major as well as secondary drains is 180 km. The storm water drains also function as sullage carriers. A few drains are flowing to their full capacity even in the dry weather and after only a light rainfall these drains start over flowing. Encroachments along and over the drains have further deteriorated the situation. Dumping of solid waste into drainage system is very common.

As mentioned earlier, topography of Lahore is comparatively flat with a mild slope towards south western side. There are natural barriers like River Protection Bund along River Ravi, Railway Track which divide the city into Northern and Southern parts and the canal which runs east – west and is situated on the ridge. The following five major natural channels run on the lowest contours and finally discharge into River Ravi [Figure 3]:

1. Upper Chotta Ravi (Northern Area)
2. Lower Chotta Ravi (North Western Area)
3. Sukh Nehr (North Eastern Area)
4. Mian Mir (Central Area) Drain
5. Satto Katla – Hudiara Drain (Southern Area)

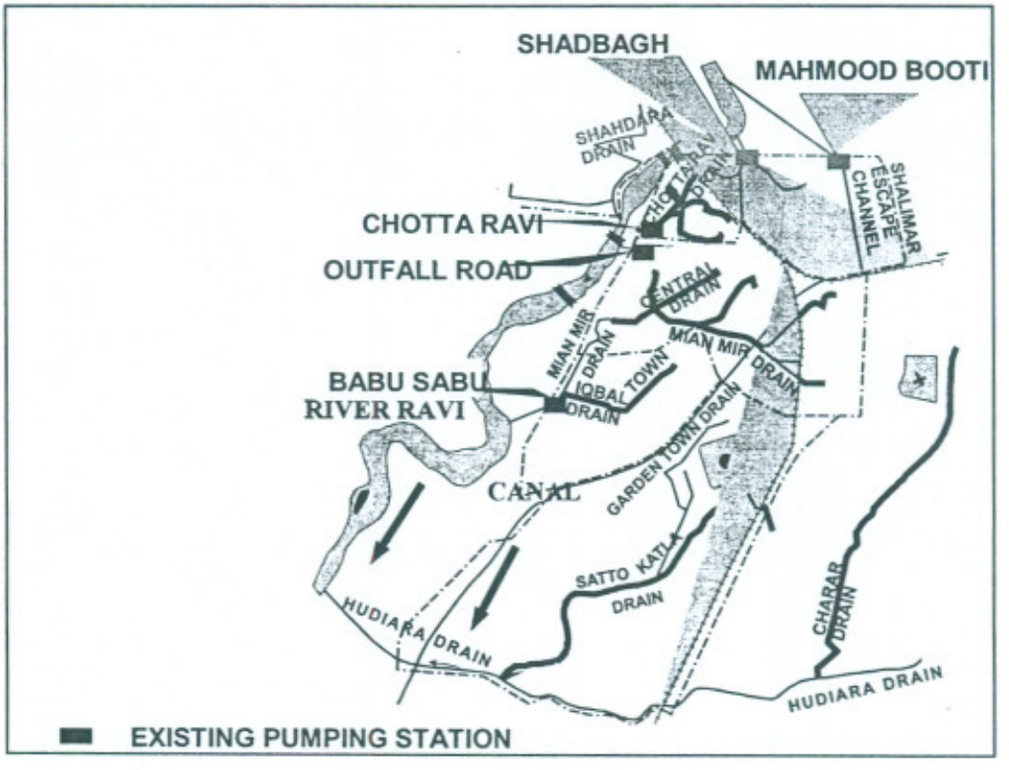


Figure 3 - DRAINAGE SYSTEM

Due to non-existence of right of way, it is difficult to properly clean the drains. 52% of the drains are cleaned mechanically and 48% manually. Disposal of sewerage and industrial wastes and dumping of solid waste into drains is causing reduction in their capacities and source of pollution and environmental hazard.

Flood protection facilities for the city are considered adequate for flood peaks upto 7100 m3/Sec. For higher floods, Shahdra Distributary Bund is breached causing extensive damage to life and property on the Right Bank of River Ravi. Waterway at Shahdra is constricted due to road and rail bridges. The encroachments in the flood plain have further reduced the discharge capacity.

5) INDUSTRIAL EFFLUENTS

Most of the industrial units are located in three (3) major industrial estates discharge their effluents into River Ravi. These major industrial complexes [3] are briefly described below:

(i) Kala Shah Kaku Industrial Complex: In this industrial complex, wastewater generated from various industrial installations is discharged untreated into Degh Nullah at an estimated rate of 50,000 m^3/d with a BOD_5 load of 41 T/d.

(ii) Lahore Township Industrial Estate: The estimated present flow rate and the waste load discharge from the estate are approximately 25,000 m^3/d and 51 T/d.

(iii) Sheikhupura Road Industrial Complex, Sheikhupura: The major polluters in this complex discharge about 30,800 m^3/d of wastewater with a BOD_5 load of 21 T/d.

Waste minimisation not only reduces treatment cost but also cuts down production cost. Waste minimisation includes inventory management, production process modification, volume reduction and recovery need to be applied to reduce wastes discharged to the environment as well the input of the treatment plant and ultimately will reduce load on River Ravi.

6) SOLID WASTE MANAGEMENT

Average per capita sold waste generation in the city ranges between 0.50 to 0.55 kg per day. On this basis, it is estimated that presently over 3,200 T/d of solid waste is generated in Lahore.

Presently solid waste generated in Lahore is collected from the communal bins placed at various locations in the city and transported for open dumping. The existing solid waste is not very effective and some of the solid waste generated in the city finds its way into open drains, sewers, streets or in open areas. It is estimated that only 70% of the total solid waste is collected [2].

There are about 40 government hospitals located within the city, out of which only two have incinerators in working conditions as a means of treatment for the waste generated in the hospital. The remaining hospitals including those in the private sector do not have any proper system and waste so generated is mixed with the municipal waste which is a potential health hazard and also not environmentally friendly. Recently Shalamar Hospital has installed an incinerator for their use and can accommodate some waste from other hospitals also.

City District Government intends to adopt composite method of solid waste at Mahmood Booti Land Fill Site. A recent study indicates that the site is still suitable for sanitary landfill development through proper engineering practice and alternate technologies including compositing alongwith resource recovery could be effectively introduced to reduce the scale of the existing problem being the first pilot project for the city of Lahore.

7) AIR QUALITY

With the rapid increase in the population of the city coupled with the growing living standards, the number of vehicles plying on the roads of Lahore has increased manifold. The vehicular traffic combined with the uncontrolled emissions from the industrial units located in and around the city has created an adverse impact on the air quality of the city.

Air quality/noise levels monitored by Environmental Protection Department (EPD) at various locations in the city are given in Table 1.

TABLE 1

AIR POLLUTION MEASUREMENTS RECORDED BY EPD AIR MONITORING UNIT AT VARIOUS BUSY CENTERS OF LAHORE

SITE	AREA	NO_2 ppb		CO ppm		DUST ug/m^3		NOISE db(A)	
		1994	1995	1994	1995	1994	1995	1994	1995
Chowk Yateem Khana	Road Side	30-77	31-80	05-40	06-40	500-1800	700-2000	75-116*	80-121*
Chowk Assembly Hall	Road Side	28-60	28-62	04-31	05-33	300-750	303-790	65-97	66-101
Badami Bagh	Industrial	25-35	25-37	03-09	03-10	450-2500	450-2500	72-99	73-104
Kot Lakhpat	Industrial	20-32	20-33	03-07	03-08	450-980	450-980	68-97	70-103
Model Town	Residential	11-18	11-20	03-05	03-06	225-600	225-600	50-80	52-85
Islampura	Residential	10-15	12-18	03-05	03-08	350-550	350-550	52-88	55-91

US Ambient Air Standard:

Noise (Residential) = 52-57 db(A), PAK-NEQS (noise) = 85 db(A)
NO_2 = 50 ppb, CO = 9 ppm, Dust = 260 ug/m^3

Noise levels above 96 dbA were normally measured when pressure horn were blown

Reported Frequency of Measurement = once/week
Source : EPD Punjab, Lahore

Similarly Air Pollutants have also been monitored at Mall/Canal Intersection by NESPAK in year 2000 and projected upto the year 2015 in connection with the studies for the following alternatives:

Alternative 1 - At grade improvement of intersection
Alternative 2 - Grade Separation with Canal Bank Road through Underpass
Alternative 3 - Grade Separation with Mall Road thróugh Fly Over.

Results are presented in Tables 2, 3 & 4. It would be seen from these Tables that pollutant emissions are expected to be minimum with the construction of Underpass (Alternative 1) as compared to the other alternatives.

Table 2

AMBIENT EMISSIONS
MALL/CANAL INTERSECTION
CARBON MONOXIDE (CO)

Year	Present and Projected Emission(kg)		
	Alt - 1	Alt – 2	Alt - 3
2000	3661	2328	2399
2005	5231	3256	3498
2010	6977	4276	4633
2015	8923	5359	5844

Table 3

AMBIENT EMISSIONS
MALL/CANAL INTERSECTION
NITROGEN OXIDES (NO_x)

Year	Present and Projected Emission(kg)		
	Alt - 1	Alt – 2	Alt - 3
2000	321	317	315
2005	409	404	399
2010	497	488	483
2015	585	574	570

Table 4

AMBIENT EMISSIONS
MALL/CANAL INTERSECTION
HYDROCARBONS (HC)

Year	Present and Projected Emission(kg)		
	Alt - 1	Alt – 2	Alt - 3
2000	900	712	717
2005	1193	936	951
2010	1493	1162	1184
2015	1802	1392	1421

8) CONCLUSIONS AND RECOMMENDATIONS

It can readily be concluded that existing infrastructure and environmental needs definite improvement in order to provide better living conditions to the citizens of Lahore. This is possible through the cooperation of all concerned individuals, private and government institutions, etc. In this regard, some recommendations are made as under:

- Excessive use of potable water should be avoided by all;
- All concerned should give due attention to leaking appliances, fittings, pipes;
- Storm water and sewage should not be allowed to mix as far as possible;
- Storm water drains should be recommended after removal of encroachments for increasing capacities;
- Solid Waste should not be thrown into the drains/sewers;
- Reduction, Reuse and Recycling of solid waste needs to be highlighted;
- Medical Waste must be handled separately;
- Septic Tanks should be provided in big plots and Interceptors in small plots under Bye-Laws;
- Proper collection and ultimate disposal of sewage and solid waste required;
- River Ravi should be saved from indiscriminate discharge of municipal and industrial wastewater affecting fish life and downstream users;
- Recharge of aquifer through percolation wells using rain water and treated effluent should be considered;
- Vehicles need to be properly tuned on regular basis for which standard workshops could be established for providing cheaper services;
- Vehicle fitness certificates should be issued based on emission of air pollutants;
- More green areas should be developed and number of evergreen plants be increased at appropriate places;
- Mass awareness campaign through print and electronic media needs to be increased at all levels; and
- National Environmental Quality Standards should be enforced without further delay in view of forthcoming WTO (World Trade Organization) requirements.

9) REFERENCES

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DRINKING WATER CONTAMINATION AND IT'S DISINFECTION

By

*Engr. Pir M. Jamil Shah

ABSTRACT

High quality water is necessary for the survival of human life. In this paper, an effort has been made to highlight the various causes of water contamination. Some of the most common impurities present in water are pathogenic microorganisms alongwith organize and inorganize pollutants. Different treatment methods are adopted to ensure the potability of water. They include physical, chemical and ultraviable treatment alongwith solar disinfection etc. The adoption of a particular disinfection strategy depends on the level of treatment required and the resources available to carry out such a treatment.

1) INTRODUCTION

It is being said that water is life, I would like to add to it that;

1. Water Quality is essential to all of us and the quality of water, affects the quality of our lives

2. High quality water, in the right quantity at the right place at the right time, is essential health, recreation and economic growth

3. Clean water is one of the most valuable resources of our planet

By definition clean water means water that has been disinfected for bacteria, viruses and other pathogens by treatment methods that do not add new danger to its quality.

In general, water contains some impurities. It usually dissolves the substances that it comes in contact with.. At certain level, minerals, just like man-made chemicals, are considered as contaminants that can make water unpalatable or even unsafe.

Water of high quality can be characterized by an absence of harmful chemicals or microorganisms.

2) HOW WATER GETS CONTAMINATED?

Water contamination takes place because accidents happen, mistakes are made systems wear out, toxic chemicals are released into the environment which find their way into the surface and ground water.

Water that is reasonably contaminant free at one moment can become dangerously contaminated at the next moment because of an accident, neglect, or any natural event.

3) WHAT ARE CONTAMINANTS?

Normally, contaminants present in drinking water are microbes, viruses, bacteria, pathogenic microorganisms alongwith organic and inorganic pollutants etc. However, in order to maintain water quality, standards have been developed to minimize the chemical and microbial risks.

* Deputy Director, WASA, Lahore

4) WATER DISINFECTION METHODS

Every technique of disinfection has its specific advantages and disadvantages. Depending on the level and nature of treatment, suitable techniques can be applied to attain the desired results. The different types of disinfection strategies are described as under;

1. Physical Methods

Physical principles for disinfection such as ultra-sound, ultra filtration, heating freezing and ionizing radicals and disinfecting small quantities of water by heat treatment by using normal methods of heating or solar energy which is technology with some potential but requires further development.

Physical methods include ultrasound, ultra-filtration, heating. In addition, disinfection through solar energy and ionizing the radicals is also very common.

2. Chemical Methods

The use of chlorine and some of its derivatives are proposed mechanisms for the inactivation of bacteria and viruses as an integral part of the disinfection process in water and wastewater treatment. Chlorine is the most commonly used disinfectant because it inactivates pathogens and microorganisms with little or no bacterial re-growth. Chlorine is also cheaper and readily available to use than other disinfectants.

Alternative disinfecting agents such as chlorine dioxide, UV light; and UV light in conjunction with hydrogen peroxide, are also being considered in some parts of the world.

When disinfectants are applied during drinking water treatment, chemical reactions occur in water to produce by-products. However, the risk of these by-products is far less than the risk of microbial contamination and disinfection is still warranted.

3. Chlorine Dioxide (ClO_2)

Chlorine dioxide **(CLO_2)** has been used to treat municipal drinking water in the United States and Europe for over 50 years. Use of chlorine dioxide provides a double benefit to communities because it is a more effective water purifier than chlorine and is free of chlorine's unwanted and unhealthy by-products.

Municipal water systems use chlorine dioxide in its gaseous state, which cannot be safely packaged or transported for consumer use.

4. Copper/Silver Disinfection

Another method of disinfection is the disinfection is the disinfection through electrical conductivity via Copper/Silver electrodes. The electrodes are made from a special highly purified alloy of silver and copper which are housed in a chamber of water, which is to be purified. Low level of chlorine is added to the solution. When a low voltage DC current is passed through the electrodes, the ionization process releases a stream of positively charged silver ions into the surrounding water.

The ions in combination with low levels of chlorine kill bacteria by reaching bacteria at such force that the membrane of the cell is ruptured and DNA of bacteria is disrupted by the ions. As a result, re-production of bacteria stops.

1. One advantage of this method is that it gives a fast bacteria inactivation rate, comparable to chlorine at the higher dose levels.

2. Secondly, the metal ion concentration can be controlled by varying flow rate of water and electric current.

3. No objectionable by-products are produced like free chlorine dose at high dose levels.

5. Ultraviolet Technology

Ultraviolet technology is a non-chemical approach for disinfection. In this method, nothing is added which makes this process simple, inexpensive and requires very low maintenance. Ultraviolet purifiers utilize germicidal lamps that are designed and operated to produce a lethal dosage of ultraviolet UV-C light is germicidal. It deactivates the DNA of bacteria, viruses and other pathogens and, thus destroys their ability to multiply and cause diseases.

6. Solar Disinfection of Water

Solar disinfection of water is a simple, cheap, efficient, renewable and environment friendly technique that uses solar energy to inactivate and destroy pathogenic micro-organisms present in water. The process is a combination of heating and use of ultraviolet (UV) radiation from the sun, which is sufficient to sterilize water.

The treatment consists of either filling up transparent plastic (PET plastic), or glass bottles with water and exposing them to full sunlight for about five hours or two consecutive days. To absorb more heat and raise the water temperature, the bottles are painted black on one side and placed on a black surface in the sun, with the clear side facing the sun.

The heat and UV rays kill the bacteria and water is ready for use in small quantities.

7. The Bottled Water Option

About bottled water, I would like to reproduce the report of,

H. Suffet, PhD Professor of Environmental Science & Engineering, USA
He says,

QUOTE;

"Bottled Water is not risk free. Bottled water is produced from variety of water sources, including tap water. The sources of bottled water is often used for marketing but frequently has no bearing on the safety or taste of the water"

UNQUOTE

Bottled water receives some type of treatment in the bottling facility. Each company producing bottled water is free to process the water as it deems fit. A form of ozonation disinfection is used, and no residual chlorine is added. Usually, the bottle is sealed while ozone is still present in the water. As a result, complaints of bacterial and chemical contamination alongwith taste and odor are very common.

Another problem that has been observed with the use of bottled water is that bacterial re-growth can occur, and bacteria (such as those measured by heterotrophic plate count, which are usually harmless) can often be cultured from bottled water.

The reason of preference for bottled water is the perception of greater safety with an assumed lower concentration of microorganisms and chemical pollutants. **However, tap water costs less and is at least as safe as bottled water if the drinking water standards are being met.**

5) LAHORE WATER SUPPLY SYSTEM

Lahorites are fortunate enough because of huge underground water reservoir which is sufficient for future, provided they are utilized carefully. Underground water if extracted from deep aquifer can be termed as free from chemical contamination due to its natural flow from north to south and no industrial zone. The major contamination is found in Kasur area due to leather industries. At present, there is no danger of flow of such water towards Lahore but if the rate of extraction by private sources and WASA continues at the present rate, then there is probability that the water level of Lahore might go lower than that of Kasur and eventually there would be water flow from Kasur towards Lahore.

WASA manages to provide contamination free and potable water to the residents of the city through huge water supply network.

So, for quality water supply, WASA has its own wells equipped water testing laboratory, which is being operated by qualified and experienced staff. The quality of water is regularly monitored by this cell and WHO standards are maintained. In case of any sign of localized contamination, immediate measures for removal of contamination are adopted.

WASA uses about 600 tons of Hypochlorite solution per year for water disinfection and curbing water borne diseases.

People should avoid direct water suction by electric motors from water supply lines because this also creates localized contamination during negative pressures or accumulated contaminants near defective service lines. It is advised to collect water in an underground water tank from main supply lines and then it may be pumped according to the requirements.

Potable water is a precious gift of nature. Unfortunately, larger quantity is wasted than it is used. Public awareness about its importance is very essential and we all should share this moral duty. Water should be saved because **Water is life.**

6) REFERENCES

- World Wide Web
- WASA Data Records

LAND AND GROUNDWATER IMPROVEMENT THROUGH SUBSURFACE DRAINAGE AT FOURTH DRAINAGE PROJECT, FAISALABAD

By

*Aftab H Azhar, M. Rafiq and M. N. Bhutta

ABSTRACT

The water wing of WAPDA is not only responsible for the development of water resources for agriculture but also undertakes measures for mitigation of the problems emerging as a consequence of over-irrigation to agricultural lands. Amongst various measures adopted, the subsurface drainage technology was introduced by WAPDA in Pakistan about three decades ago to combat the twin menace of waterlogging & salinity. To-date, eight subsurface drainage projects have been installed in various provinces of the country. The Fourth Drainage Project (FDP), Faisalabad was implemented during 1983-94. In this study, FDP has been evaluated in terms of improvement of land & groundwater conditions. The investigations revealed that drainage project was capable of controlling watertable between the pipelines at a depth of 100 to 150 cm below the ground level. There was also an improvement in shallow water quality (from hazardous to usable) due to installation of drainage system. The pre-project percentage of area under useable class was 23% which increased to 35% during post-project period. Where as, the area under hazardous class decreased from 48% to 34% during the post-project period. Surface and profile salinity levels were also improved. Salt affected area representing surface salinity level, decreased from 42% to 22% during post-project period. Non-Saline Non-Sodic (NS-NS) area representing profile salinity level, increased from 50% to 64% during the post-project period. The cropping intensity increased from 102% to 157% due to project implementation. Hence, subsurface drainage project is performing well in FDP area of Punjab province. However, the benefits of project can further be enhanced by improving O&M facilities, capacity building of staff as well as credit facilities to the farmers.

1) INTRODUCTION

Pakistan is bestowed with abundant water resources in the form of gigantic rivers fed from worldly renowned lofty snow and ice clad mountain peaks and rainy water, their tributaries, rivulets, hill torrents besides vast underground water reservoir. The rivers and their tributaries constitute the "Indus River System" - nearly a century old world's largest canal irrigation system which provides irrigation facilities to 36 million acres of land that corresponds to about 46% of the total cultivable area of the country (WAPDA, 2002). It is a well established fact that Pakistan's economy mainly depends on irrigated agriculture. Although, the country has a history of successful irrigation, as a results of continuous development in irrigation and resulting seepage from the canal system, agricultural lands of Pakistan have suffered from the problem of waterlogging and salinity. This situation caused threat to crop production and natural environment of the country. Hence, the Government of Pakistan (GOP) through WAPDA assigned high priority to control this problem. As such, a considerable part of the past investments (>Rs.37 billions) in water-sector has gone to drainage projects (Azhar *et al.*, 2005). The subsurface pipe drainage technology was introduced in Pakistan about three decades ago to control waterlogging and salinity. To-date, eight subsurface drainage projects have been completed in various provinces of the country. However, no systematic effort has been made to analyse the data of these systems in terms of performance evaluation.

*International Waterlogging & Salinity Research Institute (IWASRI), WAPDA-Lahore

Considering the huge investments incurred in these projects, there was a great need to evaluate the performance of these systems and to suggest improvements for future drainage systems. Keeping in view this aspect, a study was conducted by IWASRI that was funded by the National Drainage Programme (NDP). Under this study, four subsurface drainage projects viz., Mardan SCARP Project (*NWFP*), Fourth Drainage Project, Faisalabad (*Punjab*), Chashma Command Area Development Project (*NWFP*) and Mirpurkhas Tile Drainage Project (*Sindh*) were assessed in terms of their effects to improve the land & groundwater conditions in those areas. In this paper, only one site namely Fourth Drainage Project, Faisalabad (FDP) has been discussed.

2) DESCRIPTION OF FOURTH DRAINAGE PROJECT AREA

The Fourth Drainage Project is located in the south western part of Rechna Doab. It covers parts of Faisalabad, Jaranwala and Samundri tehsils of Faisalabad District. It was constructed by WAPDA during 1983-94 to control the waterlogging and salinity in about 0.35 million acres of land. The system was designed to maintain the watertable at an average depth of 122cm (4ft) below the ground surface. The construction plan of the FDP comprised of two units called Schedule-I and Schedule-II consisting of 38 and 41 sumps respectively for disposal of effluent. WAPDA maintained the subsurface drainage component of FDP for 2-3 years, after which the project was handed over to Punjab Irrigation & Power Department (PID).

3) DATA COLLECTION AND ANALYSIS

The major aim of drainage system installation is reclamation of waterlogged and saline lands. As the improvements take place in watertable and salinity conditions, the yields are expected to increase. In order to evaluate the performance of pipe drainage system in FDP area, four performance indicators namely: water table fluctuations, groundwater quality, soil (surface & profile) salinity and cropping intensity were investigated. For this purpose, relevant data were collected from various sources such as WAPDA, Provincial Irrigation & Power Departments, Agricultural Departments, and farmers' interviews. The required data were collected for three stages i.e. *before*, *during*, and *after* the installation of drainage system. The collected data were first screened for its integrity, and then processed/analysed in various ways to evaluate the performance of drainage project based on above stated performance indicators. This analysis is described in Section 4 below.

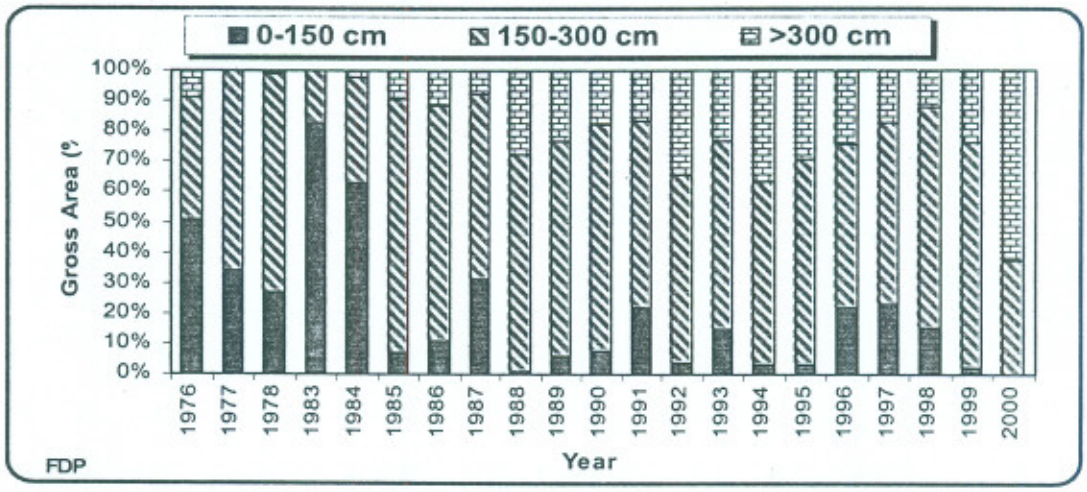
4) RESULTS AND DISCUSSIONS

In this section, the analysis of four performance indicators namely: (i) water table fluctuations, (ii) groundwater quality, (iii) soil (surface & profile) salinity, and (iv) cropping intensity are discussed.

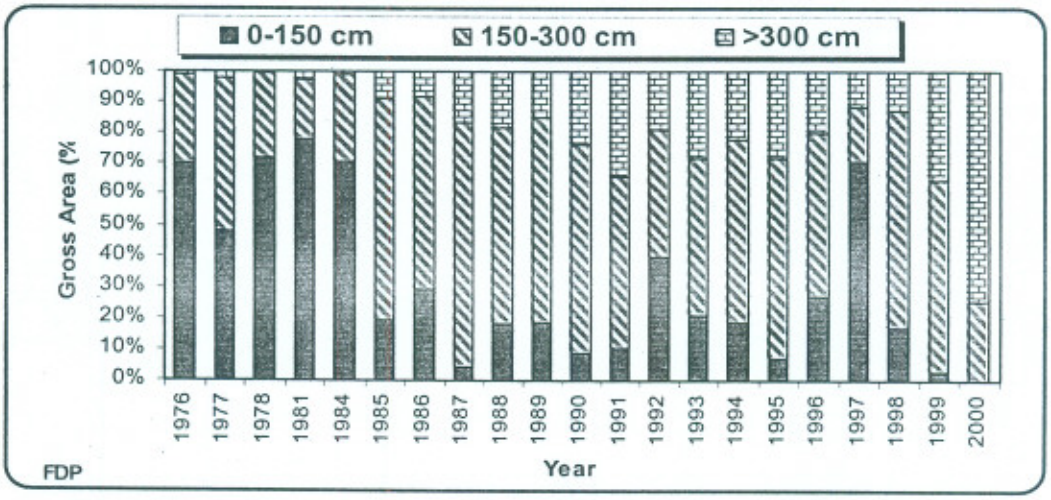
4.1 Watertable (WT) Appraisal in FDP Area

The construction period of FDP was mid-1983 to mid-1994. In this area, the water table depths surveyed during the 1984 (Bench Mark) year were at 0-150cm in 71%, 150-300cm in 28%, and >300cm in 1% of the area respectively (*Azhar et al.*, 2004). The percentage of gross area of FDP under different ranges of depths to watertable during the years 1976 to 2000 is graphically shown in Figure 1. The need for drainage is clearly demonstrated from the depth to watertable over time given in this figure. The advance of high watertables between 1976 and 1981 is evident, while the area with watertables <150cm (5 ft) deep remains nearly constant between post-monsoon 1981 and pre-monsoon 1983. In comparison, the situation in post-monsoon 1992 is less serious, but still points out the need for subsurface drainage in areas where construction had not been completed. *Pre* (year 1984) and *post-project* (year 2000) watertable depth maps of FDP area are shown in Figure 2. The design water table depth of FDP was 122 cm (4 ft). A comparison of percentage of pipe drainage area within

disaster (0-150 cm) limits for the period 1995-2000 viz 1984 (i.e. pre-project) year is graphically presented in Figure 3. As can be observed form this figure, during this period with the exception of year 1997, percentage of disaster area gradually reduced and ultimately became zero in the year 2000.

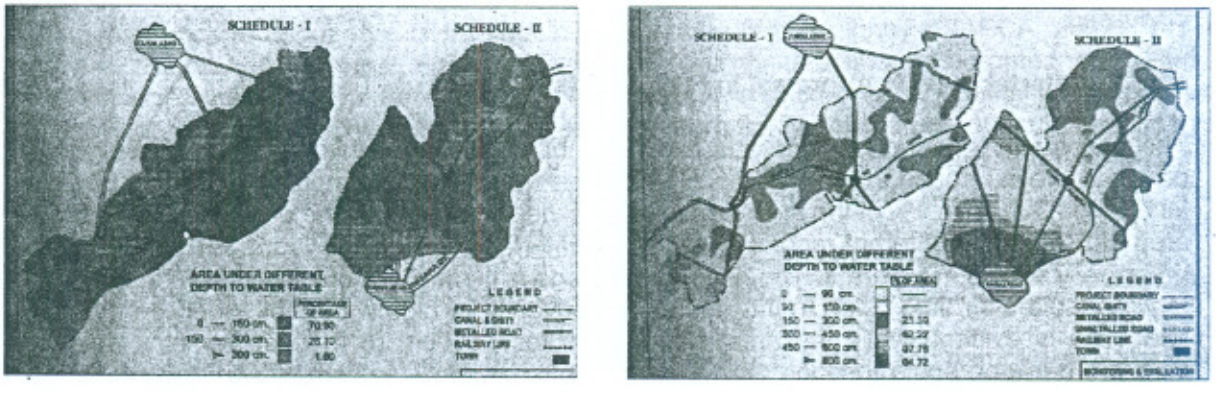


(a) Pre-Monsoon



(b) Post-Monsoon

Figure 1 - Percentage of Area under Various WT Depths at FDP



(a) Pre-project (1984) *(b) Post-project (2000)*

Figure 2 - Water table Depth Map of FDP Area (WAPDA, 2001)

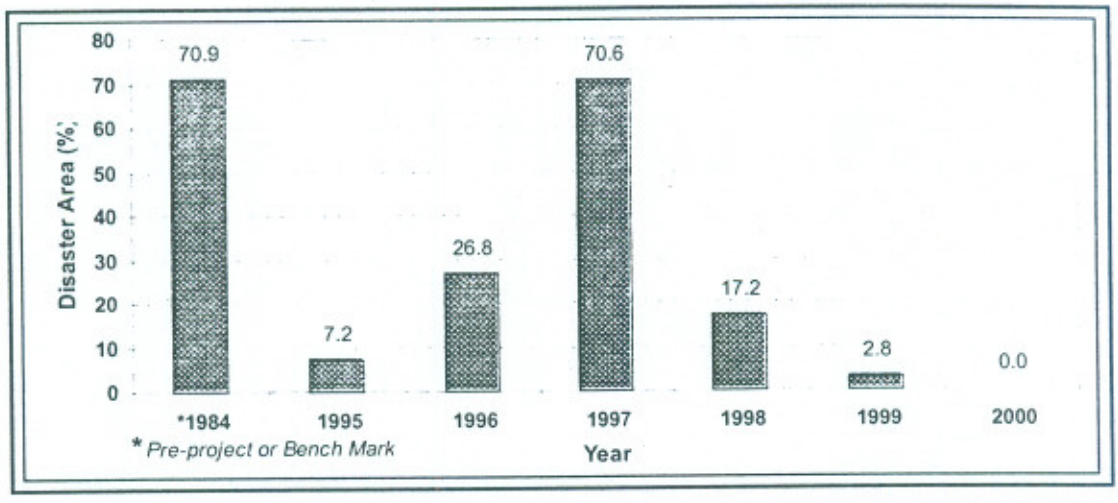


Figure 3 - Subsurface Drainage Area within Disaster (0-150 cm) Limits at FDP

The land under disaster water table went up to 70.60% in post-monsoon 1997 when the project was already completed and sumps were working partially. After that, the ground water level rapidly started falling and disaster area disappeared during 2000. The mound of ground water was developed due to extraordinary (807 mm) rains in the area during 1997. However, as can be observed (Figure 3), this mound of groundwater also dissipated with time. This was mainly coupled with groundwater travelling along natural slope towards south-west, low canal supplies during 1997-2000, and rise in temperature in the district Faisalabad (*WAPDA, 2001*). Hence, the groundwater level has been observed going down during the three years 1998–2000, and as such the disaster area totally disappeared during the year 2000. The matter of fact is that the system did not operate fully as designed (*WAPDA, 2001*). In spite of this fact, the %age of area under disaster limit became zero in year 2000. This is because, as previously reported too by *Iqbal et al.* (1997) that the watertable response to pipe drainage in most of the FDP area had indicated that the capacity of installed drainage system was higher than actual requirements. The above discussion revealed that at FDP the lowering of groundwater table cannot be attributed only to the functioning of drainage system, as it could never operate fully. The maximum pumping was done during 1995, which was 22% of the total installed capacity of sumps. Afterwards, the withdrawal by sumps went on decreasing every year and reduced to 3.90% during 2000. Since natural forces are at the back of disappearance of waterlogging, as such it is very difficult to evaluate the performance and efficiency of this system.

4.2 Groundwater Quality

Generally, the shallow (up to 30m) groundwater quality is classified into three categories namely usable, marginal and hazardous as adopted by WAPDA (Vlotman et al., 1994). Based on this categorisation, the analysis summary of water quality status observed at FDP during various years is graphically presented in Figure 4. The shallow water quality status presented in this figure revealed that there was a clear trend in the data indicating improvement of deterioration of the water qualities at FDP.

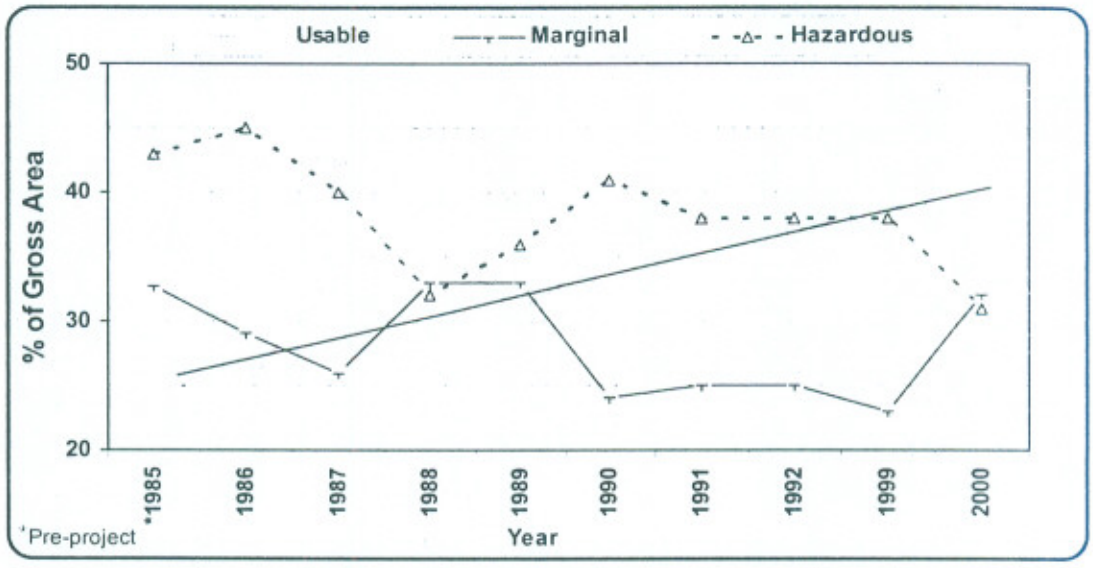


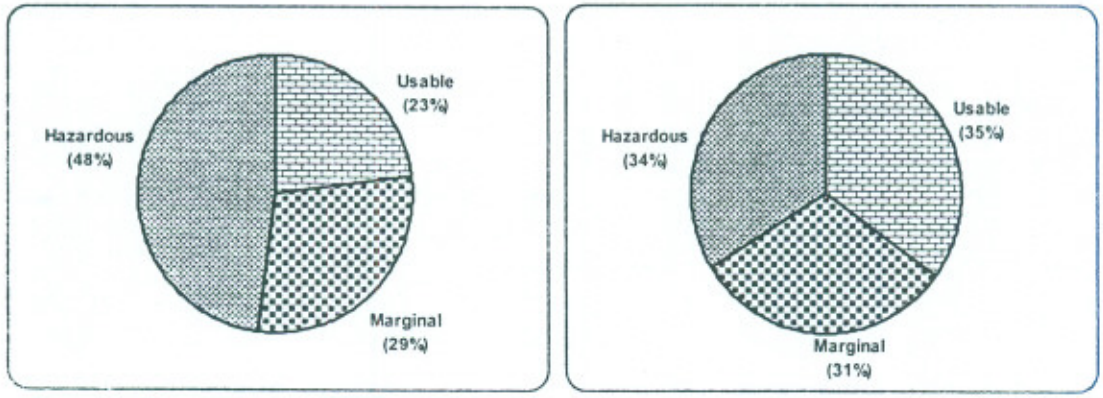
Figure 4 - Year-wise Pattern of Shallow Water Quality at FDP

Figure 5 shows the pre and post-project comparison of water quality. As shown in Figure 5, the percentage of area under hazardous water quality class reduced from 48% in pre-project year to 34% during the post-project year. Similarly, the percentage of area under usable water quality class increased from 23% in pre-project year to 35% during the post-project years. This shows an improvement in shallow water quality from hazardous to usable, as compared with the pre-project conditions. Hence, this aspect indicates positive impact of pipe drainage installation in terms of groundwater quality improvements.

4.3 Soil Salinity

Under this head, two types of salinities namely *surface salinity* and *profile salinity* are discussed as follows:

(i) ***Surface salinity:*** In order to describe the surface salinity status, four salinity classes namely: Salt Free (S1have been recognized (*WAPDA, 2001*). The details of each of these classes are given in Az), Slightly Salt-affected (S2), Moderately Salt-affected (S3), and Strongly Salt-affected (S4) har et al., 2004. Based on these salinity classes, the summary of surface salinity status observed at FDP during 1984 (Bench Mark), 1986-87, 1990-91 and 2000-01 survey is given in Table-1 and graphically presented in Figure 6.



(a) Pre-project (1985) *(b) Post-project (2000)*

Figure 5 - Comparison of Shallow Water Quality at FDP

Table 1
Surface Salinity Status During Various Surveys at FDP

(% of area)

Survey Period	Salt Free (S1)	Slightly Saline (S2)	Moderately Saline (S3)	Strongly Saline (S4)	Misc. Land Type
1984 (B.M)	56	23	10	9	2
1986-87	53	24	10	10	3
1990-91	69	8	8	9	6
2000-01	73	8	9	5	5

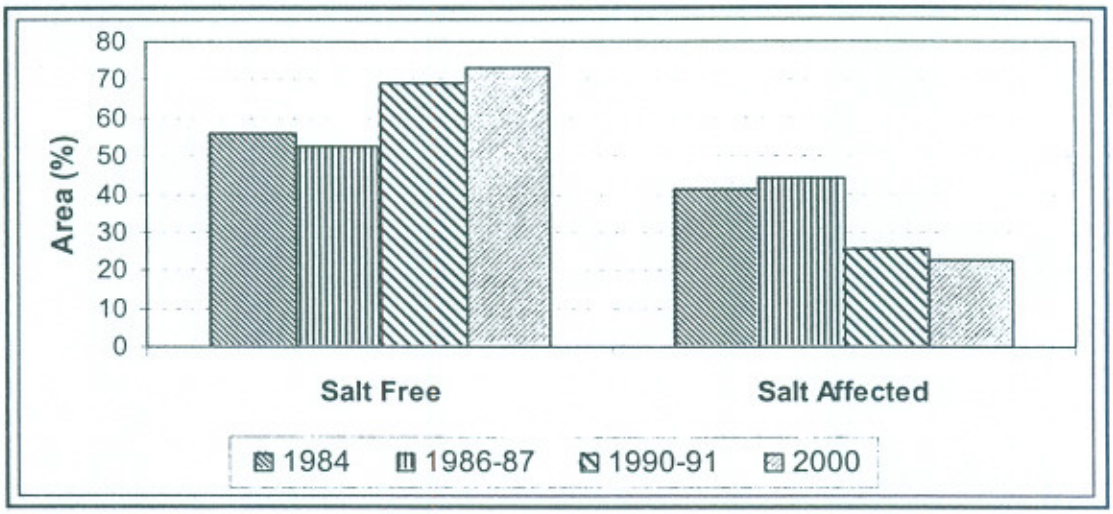


Figure 6 - Surface Salinity Status at FDP

As can be observed, *salt affected* (i.e. S2, S3 & S4) area showed a slight decrease of 19% during 2000 year over 1984 pre-project (Bench Mark) year. A significant improvement can also be observed during the latest survey period (year 2000) over bench mark (1984) year. As can be observed, during the pre-project year (1984) over to the post-project year 2000, the salt free (S1) area increased from 56% to 73% with a net increase of 17%, whereas the salt affected (S2, S3 & S4) area decreased from 42% to 22% indicating a net decrease of 20%. This improvement can mainly be attributed to the leaching of salts below 180 cm depth due to the lowering of watertable resulting from the installation of subsurface drainage system in addition to the application of irrigation water and rains. This aspect also indicates a positive impact of subsurface pipe drainage system installation in the FDP area.

(ii) ***Profile salinity:*** The profile salinity survey was carried out to determine the magnitude of hazard in the soil profile. For this purpose, the soil samples were air dried and analysed for Electrical Conductance (ECe), and Sodium Adsorption Ratio (SAR). Under this head, as per the criteria laid down in USDA Hand Book 60, the soils are classified under four classes namely: *Non-Saline Non-Sodic* (NS-NS), *Saline Non-Sodic* (S-NS), *Saline Sodic* (S-S) and *Non-Saline Sodic* (NS-S) The details of each of these classes are given in *Azhar et al.*, 2004. Based on these salinity classes, the summary of profile salinity status at FDP during various surveys is given in Table-2 and graphically presented in Figure 7. As can be observed, NS-NS area showed a significant improvement. The area under this class was 50% during the pre-project (1984) year which increased to 64% during post-project (2001) year, thus, showing a net increase of 14% over the bench mark (1984) year. Similarly, the improvement in S-S profile was of the order of 8% and in NS-S profile was 5%. Hence, it indicates the positive impact of pipe drainage system in terms of profile salinity control in FDP area.

Table 2
Profile Salinity Status for Various Surveys at FDP

(% of area)

Survey Period	Non-Saline Non Sodic (NS-NS)	Saline Non Sodic (S-NS)	Saline Sodic (S-S)	Non Saline Sodic (NS-S)
1984 (B.M)	50	4	38	8
1986-87	47	9	37	7
1990-91	61	5	30	4
2000-01	64	2	31	3

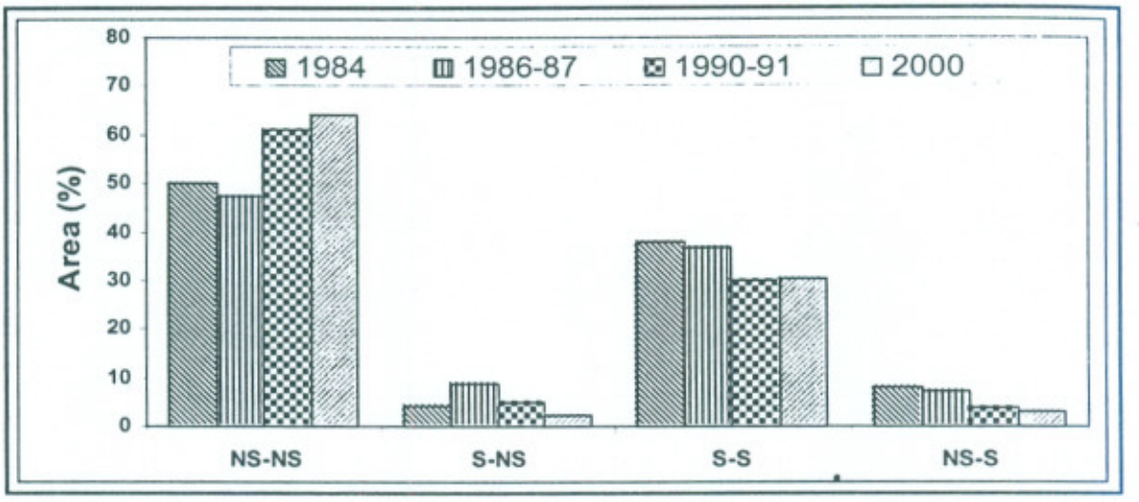


Figure 7 - Profile Salinity Status at FDP Area

4.4 Cropping Intensity

As reported by *WAPDA* (2001), in the pre-project (1986-87) year, annual cropping intensity was 144% (Kharif 58.3%, Rabi 85.7%). The overall cropping intensity was envisaged not likely to decrease. Cropping intensities have rather gone-up to 164% during post-project (1999-00) year despite the fact that water shortage became more acute due to below normal rains during the years 1998-2000. It was reported that shortage of crop water requirement was made up with the help of pumping from private tubewells installed in the area. The year-wise cropping intensities of FDP are graphically shown in Figure 8.

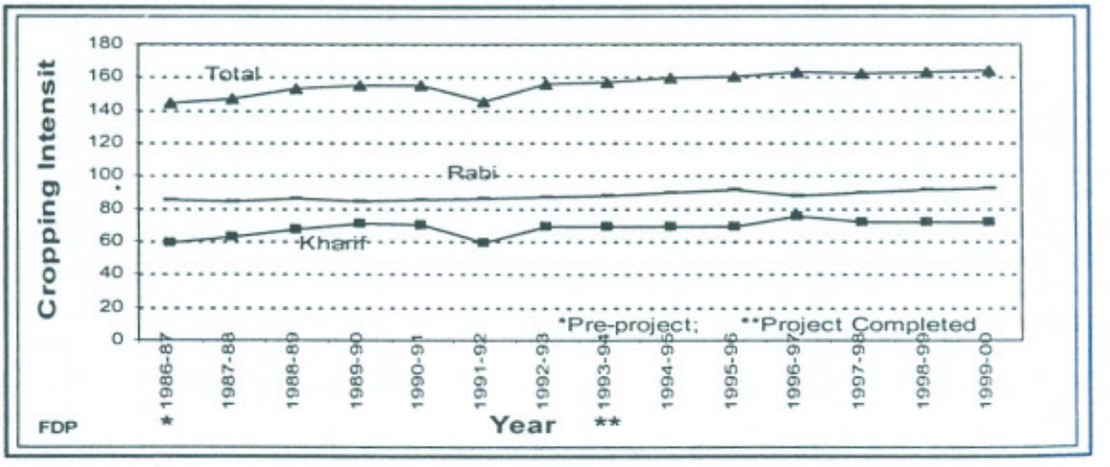


Figure 8 - Cropping Intensities during 1986-87 to 1999-00 at FDP

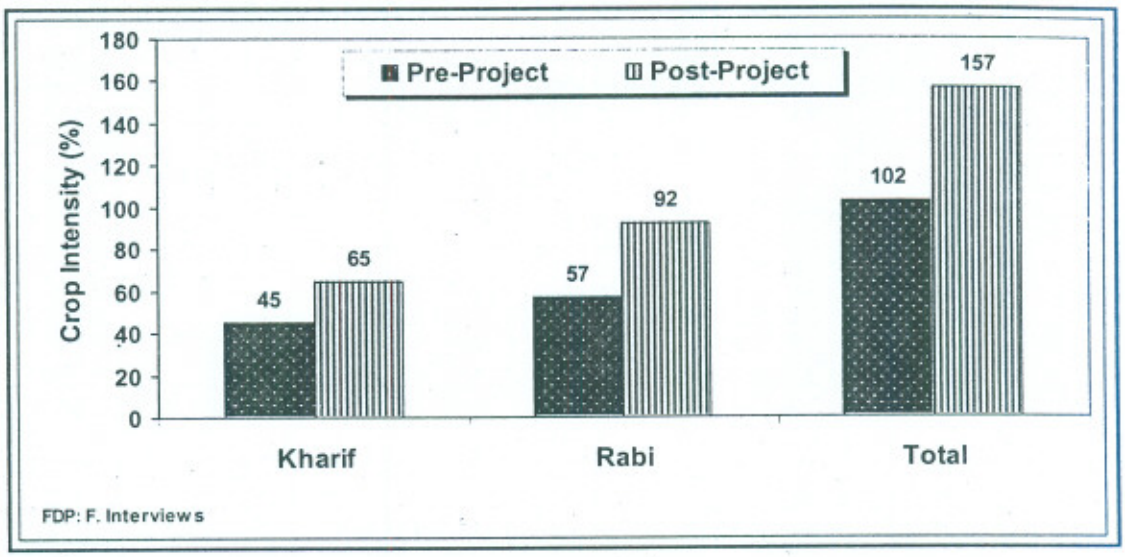


Figure 9 - Pre & Post-Project Cropping Intensities at FDP

Based on the farmer's interviews, pre and post-project (2003-04 year) cropping intensities at FDP are graphically shown in Figure 9. An increase of 55% in total cropping intensity is clearly shown in this figure as compared with pre-project conditions. Thus, the cropping intensity parameter also signifies the positive impact of pipe drainage installation in FDP area.

5) CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

Based on the analysis of performance indicators of pipe drainage system at FDP, following conclusions were drawn:

- In comparison with the pre-project conditions, the remarkable decrease in the disaster area during post-project (year 2000) signifies that pipe drainage project at FDP was capable of controlling the water table in the area.
- The water quality status analysis revealed that there was an improvement in shallow water quality (from hazardous to usable) due to installation of drainage system. The pre-project percentage of area under *useable* class was 23% which increased to 35% during post-project year. Similarly, the pre-project percentage of area under *hazardous* class was 48% which reduced to 34% during post-project year. This shows a positive impact of the project installation in the area.
- The results of surface salinity and profile salinity revealed that both salinities were significantly decreased. The decrease in surface and profile salinities was of the order of 17% and 20%, respectively, when compared with pre-project (year 1984), thus showing improvement in the salinity/sodicity status of the project soils. This indicates positive impact of pipe drainage system installation in the FDP area.
- The analysis of cropping intensity data (collected through farmer's interviews) revealed that project implementation resulted in an increase of annual cropping intensity from 102% during pre-project to 157% during post-project (2003-04) year with a net increase of 55%.
- Operation and maintenance (O&M) of pipe drainage systems demands careful and concrete measures to maintain the efficiency of these systems.

5.2 Recommendations

- Farmers' awareness regarding the need to contribute to the O&M cost of the pipe drainage systems should be encouraged. This will help them to develop in themselves a sense of ownership of the drainage systems.
- In order to find any defect/deficiencies in the pipe drains, routine inspection of pipe drains is recommended and routine maintenance should be carried out to keep the system functioning.
- The agriculture extension services should be strengthened in the drainage areas to educate the farmers regarding their feedback to the installation & operation of pipe drainage systems.

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LIST OF BANNED OR SEVERELY RESTRICTED CHEMICALS

S. No.	Name of Chemical	S. No.	Name of Chemical
1.	Binoparcryl	13.	Disulfoton
2.	Bromophos ethyl	14.	Endrin
3.	Captafol	15.	Ethyulen Dichloride+ Carbonterrochloride (EDCT)
4.	Chloroduneform	16.	Zinc
5.	Chlorobinzilate	17.	HCH (Mixed Isomers)
6.	Chlorotheophos	18.	Heptachlor
7.	Chhexatin	19.	Leptophos
8.	Dalapon	20.	Mercury Compound
9.	DDT	21.	Mevinphos
10.	Dibromochloropropane	22.	Propergite
11.	Dibromochloropropene	23.	Toxaphence
12.	Dieldrin		

Ref : Environmental Initiatives, Ministry of Environment, Government of Pakistan (2004)

AGRO-ECONOMIC ISSUES EFFECTING THE PERFORMANCE OF SUBSURFACE DRAINAGE PROJECTS

By

*Aftab H Azhar, **A. B. Sufi and Nazir Ahmad

ABSTRACT

Beneficiaries' perception regarding agro-economic issues affecting the performance of subsurface drainage projects has been investigated. For this purpose, four drainage projects namely: Mardan SCARP Project, MSP (*NWFP*); Fourth Drainage Project, FDP (*Punjab*); Chashma Command Area Development Project, CCADP (*NWFP*) and Mirpurkhas Tile Drainage Project, MKDP (*Sindh*) have been selected. At these study sites, a socio-technical survey was carried out in which randomly selected beneficiaries (i.e. farmers) were interviewed. As per the investigation, post-project water shortage has been observed to be the number one problem faced by the farmers of drainage areas. Significant percentage of respondents i.e. 92% (FDP), 75% (MKDP) and 43% (MSP) site expressed that they were not satisfied with the irrigation supplies available to them. Regarding post-project remodelling of irrigation to increase water allowances, the study revealed that at MSP & CCADP sites irrigation supplies were remodelled, however, no remodelling was done at FDP and MKDP study sites. The study indicated that almost 44% respondents at four study sites were mixing the poor quality drainage effluent/groundwater with canal water for supplementing their irrigations. The use of poor quality water was affecting in some ways the crops grown and the soil itself. Furthermore, salty water caused skin problems & other diseases in those areas. Farmers' willingness regarding salt land revegetation and/or fish ponds programme revealed that on average, 62% respondents of the study sites expressed their willingness with the condition if they were provided with financial assistance & training. It was observed that watercourse improvement could appreciably help to abate the increased irrigation demand issues of drainage areas. On average, 31% respondents at four study sites expressed that their watercourses had not been improved. If those watercourses are also improved, then the beneficial effects of drainage systems can further be enhanced in those areas. Post-project irrigation requirements are recommended to be reviewed carefully on priority basis to facilitate adequate irrigation supplies in drainage areas. In order to harvest the maximum benefits from subsurface drainage projects, the coordination among various departments such as WAPDA, Agriculture Extension Department and the Irrigation & Power Department etc. should be strengthened in those areas. Also, the credit facilities for farmers should be improved.

1) INTRODUCTION

Pakistan's agriculture is designated as irrigated agriculture having about seventeen million hectares of irrigated area mostly confined in the Indus Basin. It has been, and continues to be the most vital sector of the economy of Pakistan, contributing about 24% share in the gross domestic product (GDP). Agricultural exports account for about 70 % of total foreign exchange earnings of the country.

Furthermore, it continues to be the main source of income for about 70% of the population (Kahlown and Majeed, 2004). However, during the last half a century agricultural lands of Pakistan have suffered from the problem of waterlogging and salinity due to inadequate drainage facilities. Since, waterlogging & salinity caused threat to crop production and natural environment in the country, the Government of Pakistan (GOP) has assigned high priority to control these problems. Therefore, a considerable part of the past investments in Water Sector (about thirty-seven billion rupees) has gone to capture this twin menace. The

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subsurface drainage technology was introduced in Pakistan about three decades ago to control waterlogging and salinity. To-date, eight drainage projects have been installed in various provinces of the country. In the past, different aspects of drainage systems have been investigated (Ijaz & Davison, 1997; IWASRI, 1997; Azhar et al., 2004b&c), however, not much attention has been paid to the beneficiaries' perception regarding agro-economic issues effecting the performance of these systems. Considering the huge investments incurred and the envisaged benefits of these projects, it is very important to investigate the post-project agro-economic issues of those systems and to suggest improvements for future drainage projects. Keeping in view this aspect, the present study was conducted by IWASRI funded by the National Drainage Programme (NDP) as discussed below.

2) DESCRIPTION OF THE STUDY AREA

To tackle the twin menace of waterlogging & salinity, to-date eight drainage projects have been installed in various provinces of Pakistan. For this study, only four project sites namely; MSP (*NWFP*), FDP (*Punjab*), CCADP (*NWFP*) and MKDP (*Sindh*) have been selected. These project sites have been selected based on their wide range of geohydrological & climatic conditions. In addition, these sites cover a range of old as well as most recently installed pipe drainage systems in different provinces of Pakistan. Hence, this range of selection would facilitate to investigate subsurface drainage systems that were designed using old and new technology. The salient features of these selected project sites are given in Table 1.

Table 1
Salient Features of Selected Drainage Projects

DESCRIPTION	MSP	FDP	CCADP	MKDP
Gross Area	50,020 ha	52,609 ha.	63,509 ha	-
Subsurface Drainage Area	29,542 ha	30,351 ha.	60,936 ha	24,281 ha
Installation Period	1983–92	1988–94	1984-94	1994–97
Design WT Depth	140 cm	122 cm	140 cm	122 cm
Type of System	Gravity	Pumped	Pumped	Pumped
Total cost	Rs $673x10^6$	Rs $1127x10^6$	Rs 1127.8 m	Rs 2473 m

(After Azhar et al., 2004a)

3) DATA COLLECTION AND ANALYSIS

In this study, beneficiaries' perception regarding agro-economic issues of subsurface drainage projects has been investigated. For this purpose, a survey was carried out by IWASRI consultants at four study sites in which randomly selected beneficiaries were interviewed about post project agro-economic issues of their drainage areas. The sample questionnaire developed for this survey is given in Azhar et al. (2004a). The collected data were first screened for their integrity and then analysed in various ways to arrive at the desired assessment of four drainage projects selected for this study.

4) RESULTS AND DISCUSSIONS

Before discussing the agro-economic issues of various project sites, it is worth mentioning that literacy rate is the yardstick of development & socio-economic conditions of the drainage area. Literate farmers are better able to gain access to new ideas and technologies through the dissemination of pamphlets and posters. By the same token, they can communicate better and provide reliable information during the socio-technical surveys/interviews such as conducted for this study. In view of its importance in drainage areas, literacy information of four study sites as given in Azhar et al., (2004a) were collected. Their investigations revealed that significant (~77%) population of respondents at four study sites was educated. The overall education status at four study sites in the order from illiterate to the highest level schooling can be listed as: Illiterate (23%), Primary (12%), Middle (14%), Matric (18%) and F.A./F.Sc$^+$ (33%). This literacy status information indicates how reliable/sound information have been collected for this study. With regards to farmer's awareness about usefulness of subsurface drainage systems, it was reported that almost 99% of the respondents did acknowledge the positive effects of drainage systems on land & water conditions of their areas. The post project agro-economic issues of various project sites are discussed as below:

4.1 Watercourse Improvement Status

One of the major effects of subsurface drainage is the increased irrigation demand by the crops in the drainage areas. It is mainly because of the decreased sub-irrigation which results due to the operation of subsurface drainage system in the area. Furthermore, to reclaim the salt affected lands of drainage areas, extra irrigation supplies are required to leach down the excess salts. As significant portion of water loss can be checked through watercourse improvement, hence, watercourse improvement can appreciably help to abate the extra irrigation requirement issue of drainage areas, thus, enhancing the beneficial effect of subsurface drainage systems in those areas. The status of watercourse improvement as expressed by the respondents at four study sites is given in Table 2.

Table 2
Distribution of Respondents by Virtue of Watercourse Improvement

Project Area	Status of Watercourses Improvement (%)+	
	Yes	*No*
MSP	57	43
FDP	91	9
CCADP	80	20
MKDP	50	50
Overall	*69*	*31*

+ *Percentages based on the number of respondents.*

As can be observed, at MSP, FDP, CCADP and MKDP study sites, 57%, 91%, 80% & 50% respondents respectively, expressed that their watercourses had been improved. However, 43% (MSP), 9% (FDP), 20% (CCADP) and 50% (MKDP) respondents revealed that their watercourses had not then been improved. If those watercourses are also improved, then the impact of subsurface drainage system can further be enhanced in those areas. It is worth mentioning that in this study, improved watercourse means lined and/or earthen improved watercourses.

4.2 Satisfaction Regarding Irrigation Supplies

The drainage beneficiaries face multiple problems with increasing their agricultural production, ranging from the quality of land to the non-availability of other inputs of production. As mentioned earlier, increased irrigation demand because of limited sub-irrigation is one of the major impacts of subsurface drainage systems. Secondly, to reclaim the salt affected lands in drainage areas, extra irrigation supplies are also required for leaching down the excess salts. If adequate irrigation supplies are made available, the beneficial impacts of drainage systems can further be enhanced in those areas. The respondents were asked to mention their satisfaction level regarding post-project irrigation supplies. The percent distribution of respondents regarding this aspect for four study sites is graphically shown in Figure 1.

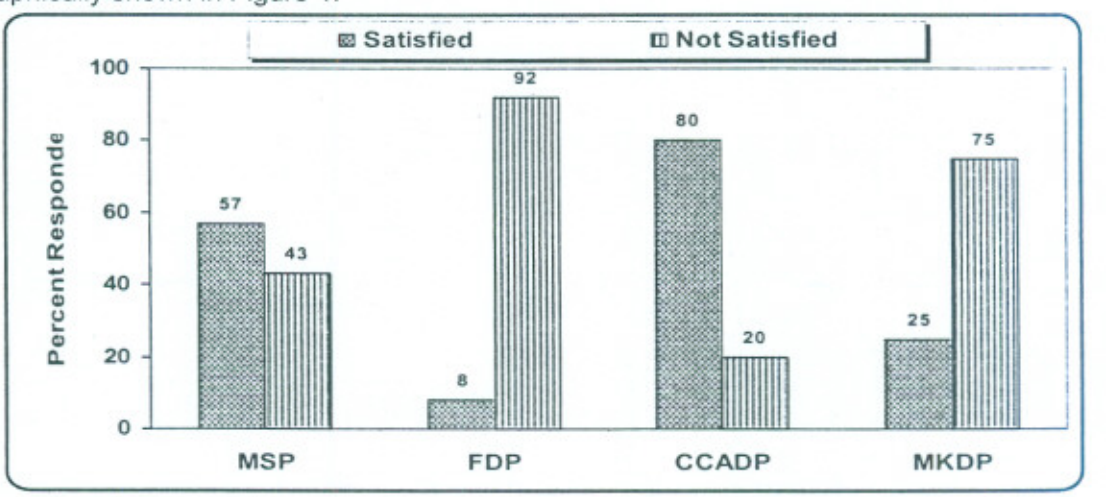


Figure 1 - Satisfaction Status of Irrigation Supplies at Four Study Sites

As can be observed (Figure 1), significant percentage of respondents i.e. 92% and 75% at FDP & MKDP sites expressed that they were not satisfied with the irrigation supplies available to them. The MSP site (43%) was second in number followed by these two sites in this regard. These results are in line with the findings of Ijaz and Davison (1997) who reported water shortage to be the number one problem faced by the significant majority of farmers in drainage areas. As can be observed, at CCADP site, 80% of the respondents expressed their satisfaction over irrigation supplies available in that area, the main reason that CRBC was contributing good quality seepage water in that area. This analysis indicates that if adequate irrigation supplies are provided, the beneficial effects of drainage systems can further be enhanced in those areas.

4.3 Remodelling of Water Allowances

When asked about post-project remodelling of irrigation supplies to increase water allowances in drainage areas, the respondents' distribution regarding this aspect for four study sites is graphically shown in Figure 2. As can be observed, significant percentage of respondents i.e. 86% & 90% at MSP and CCADP expressed that irrigation supplies were remodelled to increase the water allowances in those areas. However, no remodelling of irrigation has been done at FDP and MKDP study sites. This analysis indicates that irrigation supplies should be remodelled at FDP and MKDP study sites to increase the water allowances at those areas.

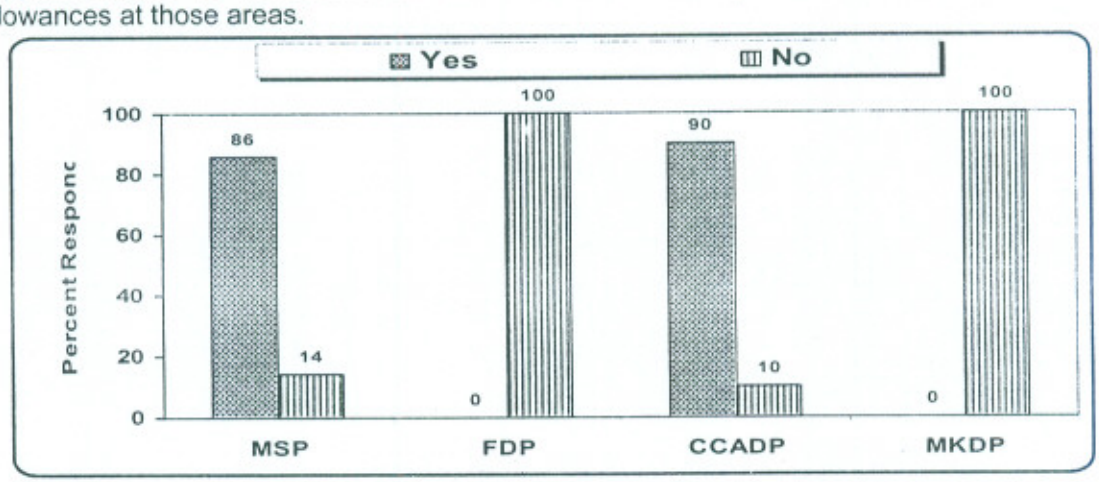


Figure 2 - Remodelling of Irrigation to Increase Water Allowances at Four Study Sites

4.4 Groundwater Quality Improvement

Normally, the quality of groundwater is indicated by three categories namely *usable, marginal,* and *hazardous*. Beneficiaries were asked about the current status of quality of groundwater in their areas, and also asked whether they were mixing that groundwater with the canal water to supplement their irrigation. In this regard, the percent respondents about three categories of groundwater quality at four study sites are given in Table-3. As can be observed, 79%, 33% & 100% of the respondents at MSP, FDP & CCADP sites, respectively expressed that groundwater quality was improved from *hazardous* to *usable* class due to drainage activity. However, 21%, 50% & 100% respondents at MSP, FDP & MKDP sites respectively, expressed that the groundwater quality was *marginal*. Whereas, 17% respondents at FDP expressed as *hazardous*. As far the conjunctive use is concerned, respondents reported that although the groundwater quality was not fully improved, yet they had been mixing the groundwater with canal water for supplementing their irrigations. The percent respondents for conjunctive use are graphically shown in Figure 3. The significant percentages of respondents in this regard at FDP (92%) and MKDP (50%) highlighted the shortage of irrigation supplies in those areas. A low percentage of respondents at MSP (14%) and CCADP (20%) indicated relatively less shortage of irrigation supplies in those areas.

Table 3
Respondents Perception of Groundwater Quality and its Conjunctive Use

Project Area	Quality of Groundwater (%)[+]			Conjunctive Use (%)[*]
	Usable	*Marginal*	*Hazardous*	
MSP	79	21	-	14
FDP	33	50	17	92
CCADP	100	-	-	20
MKDP	-	100	-	50
Overall	*53*	*43*	*4*	*44*

[+] *Percentages calculated from the number of farmers having perception about specific category of groundwater quality;*
[*] *Percentages calculated from the number of farmers mixing groundwater with canal water to supplement irrigation.*

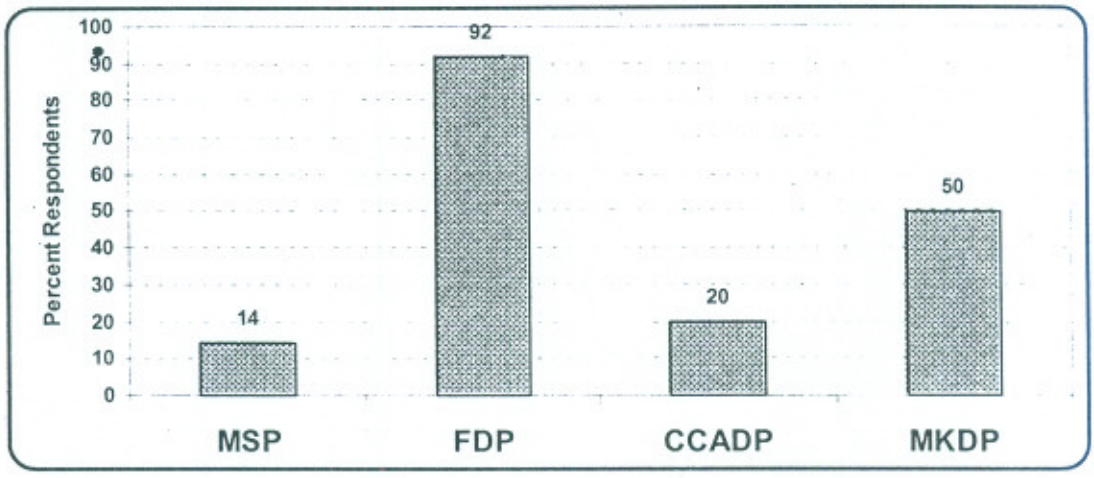


Figure 3 - Percentage of Respondents for Conjunctive Use of Ground Water at Four Study Sites

4.5 Drainage Effluent Quality Improvement & its Reuse

The *drainage effluent* quality is expressed in three classes viz; *fit, marginal*, and *unfit*. The percent distribution of respondents about drainage effluent quality at four study sites is given in Table-4, and graphically shown in Figure 4. As can be observed, 64 %, 33% & 100% of the farmers at MSP, FDP & CCADP respectively expressed that drainage effluent was *fit* for irrigation, whereas only 9% at FDP and 25% at MKDP considered it as *unfit* for irrigation. At the same time, 36 % (MSP), 58% (FDP) and 75% (MKDP) considered it as *marginal*. It is interesting to note that majority of the farmers knew that government i.e. WAPDA and/or Provincial Irrigation & Power Department authorities had prohibited the use of drainage water because of its poor quality. Although, it was advised during the early stages after the installation (i.e. start of the operation) of subsurface drainage systems, yet, during the interviews on enquiring about the reuse of drainage water for irrigation, the farmers were reluctant to tell the truth. It was mainly due to the fear of any penalty and/or revenue charges to be imposed on them by the government. Despite the above mentioned awareness, majority of the farmers was using the drainage effluent to supplement their irrigation due to shortage of irrigation supplies, and was suffering from certain side effects on their crops & lands due to the use of poor quality drainage effluent. This was mainly due to their lack of knowledge about the use of poor quality drainage effluent.

Table 4
Respondents Perception about Drainage Effluent Quality

Project Area	Drainage Effluent Quality Status (%)[+]		
	Fit	*Marginal*	*Unfit*
MSP	64	36	-
FDP	33	58	9
CCADP	100	-	-
MKDP	-	75	25
Overall	*49*	*42*	*9*

[+] *Percentages calculated from the number of respondents*

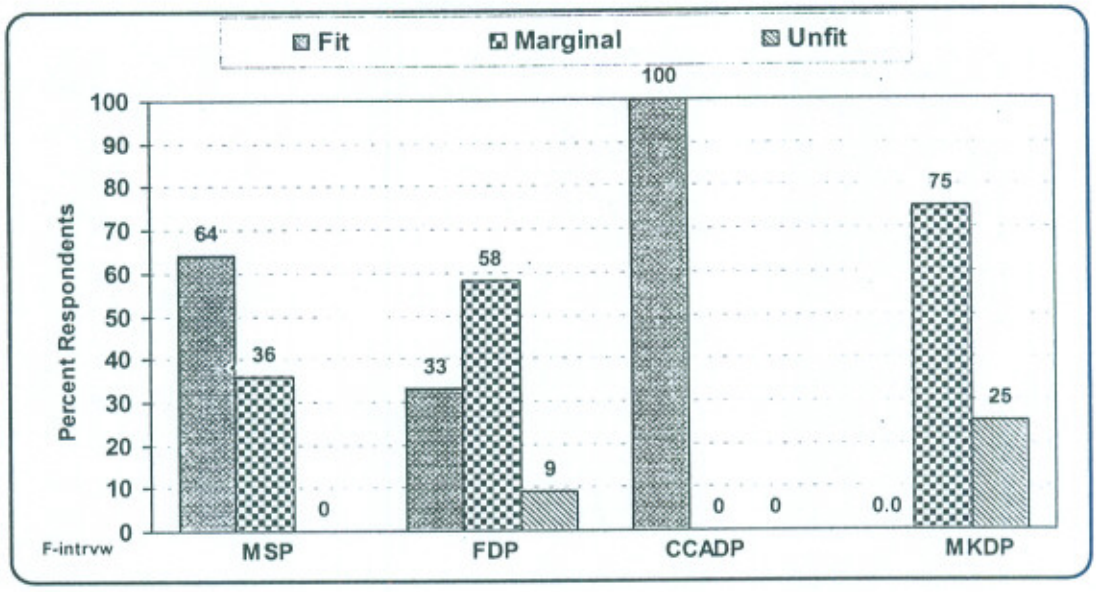


Figure 4 - Graphical Representation of Respondents Perception about Drainage Effluent Quality

4.6 Drinking Water Quality Improvement

The percent distribution of respondents regarding their perception about drinking water quality improvement at four study sites is graphically shown in Figure 5. As can be observed, at MSP, FDP, CCADP & MKDP sites 100%, 75%, 40% & 75% respondents, respectively, expressed that there was an improvement in the drinking water quality due to installation of drainage systems in those areas. Improvement in quality of drinking water indicates reduction in waterlogging problem. Nevertheless, an appreciable percentage of respondents at FDP (25%), CCADP (60%) and MKDP (25%) told that there was no improvement in drinking water quality. As such, this aspect did indicate the existence of drinking water quality problem in those areas. In this regard, the general comments recorded during the survey were; i) water quality was still poor, ii) there was no government water supply scheme, iii) due to bad quality water, things did not get cooked properly, and iv) salty water caused skin problems and other diseases.

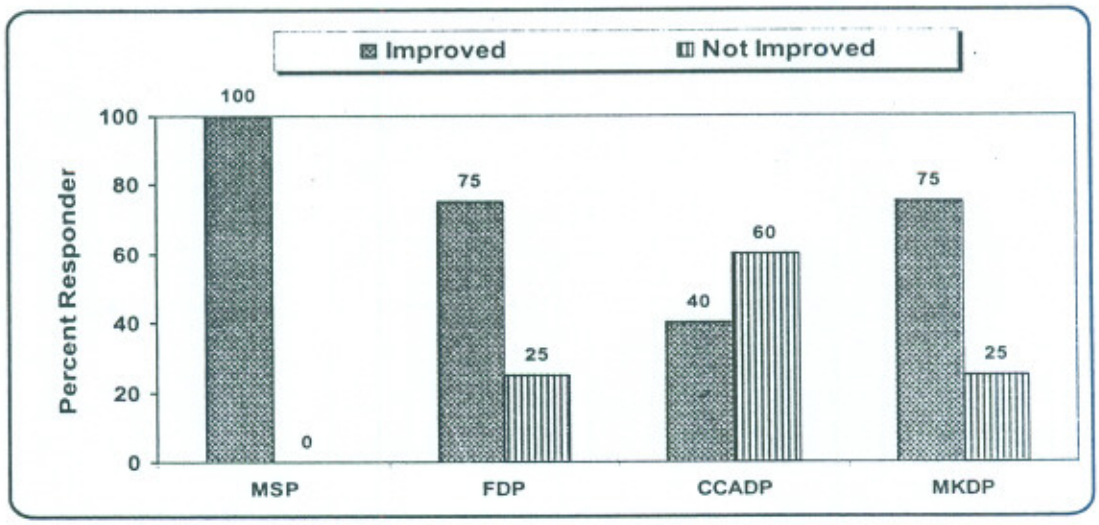


Figure 5 - Respondents Perception about Drinking Water Quality Improvement

4.7 Salt Land Revegetation and/or Fishpond Programme

In drainage areas, there are certain lands that had been reclaimed from waterlogging problem through drainage activity. However, those lands could not be brought under cultivation for growing food-crops due to any of the reasons such as; limited capital resources of farmers, shortage of irrigation supplies, or highly saline conditions of the land etc. Under these circumstances, the idea of adoption of Saline Agriculture Technology (SAT) by the farmers could be quite useful. The SAT activity may include growing of eucalyptus trees for salt tolerance, growing of Atriplex (saltbush) shrubs or salt tolerant grasses for potential use as animal fodder, and development of fish ponds in salt lands (Ijaz and Davison, 1997). Therefore, during the socio-technical survey of this study, the farmers were told that their reclaimed lands could be brought under use through salt land revegetation/agro-forestry programme and/or fish pond activities. Hence, during the survey farmers' willingness was enquired regarding the adoption of salt land revegetation and/or fishponds programme. The percent distribution of respondents regarding this aspect for four study sites is given in Table-5 and graphically shown in Figures 6 and 7.

As can be observed (Figure 6), at MSP, FDP, CCADP & MKDP study sites 71%, 92%, 20% & 75% respondents respectively, expressed their willingness to grow agro-forestry at their salt lands. Whereas, 29% (MSP), 8% (FDP), 80% (CCADP) and 25% (MKDP) respondents did not show any willingness to grow agro-forestry at their lands. It is worth mentioning that even those farmers, who showed their willingness, were willing with the condition if they were provided nursery plants and some financial help along with some training.

Table 5
Percent Distribution of Respondents Regarding Their Willingness About Salt Land Re-vegetation and/or Fishponds Programme

Project Area	Re-vegetation and/or Fishponds Programme (%)+			
	Agro-forestry		Fishponds	
	Yes (%)	*No (%)*	*Yes (%)*	*No (%)*
MSP	71	29	50	50
FDP	92	8	100	-
CCADP	20	80	10	90
MKDP	75	25	75	25
Overall	*65*	*35*	*59*	*41*

+ *Percentages calculated from the number of respondents.*

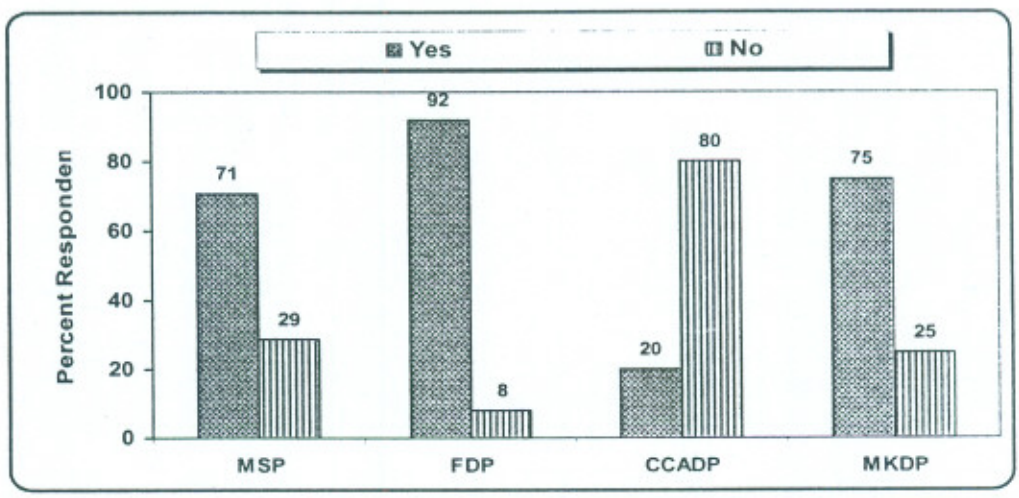


Figure 6 - Willingness About Salt Land Revegetation at Four Study Sites

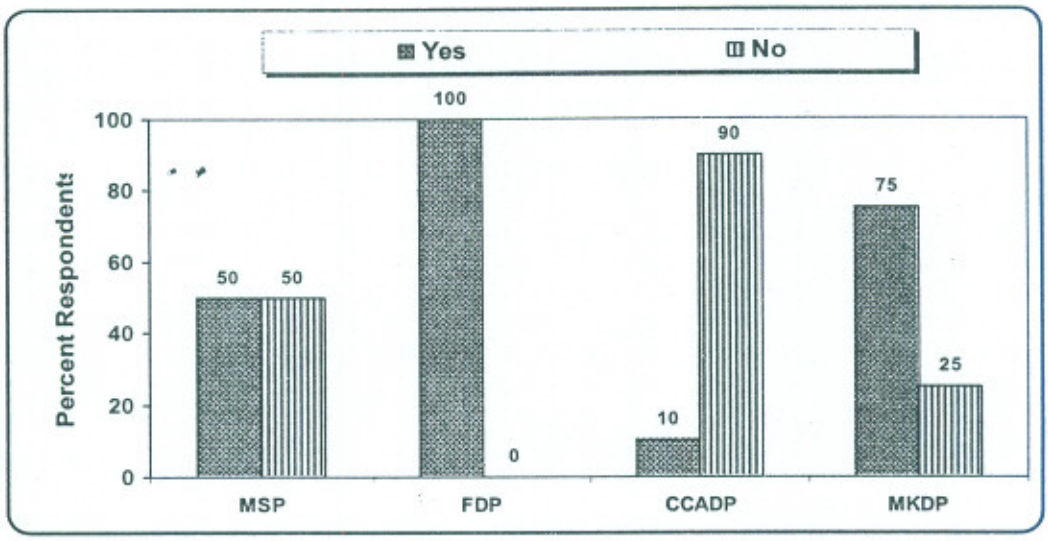


Figure 7 - Willingness About Salt Land Fishpond Programme at Four Study Sites

With regards to fish ponds activity, Figure 7 indicates that at MSP, FDP, CCADP and MKDP study sites 50%, 100%, 10% & 75% respondents respectively, showed their willingness for fish culture programme at their salt lands. Whereas, 50% (MSP), 0% (FDP), 90% (CCADP) and 25% (MKDP) respondents did not express their willingness for fish ponds programme. Again, it is worth mentioning that even those farmers, who did show their willingness, were willing with the condition if they were provided with financial assistance and free training.

5) CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

i) Post-project water shortage has been observed to be the number one problem faced by the farmers of drainage areas. When asked about satisfaction regarding post-project irrigation supplies, significant percentage of respondents i.e. 92% (FDP), 75% (MKDP) and 43% (MSP) sites expressed that they were not satisfied with the irrigation supplies available to them.

ii) Regarding post-project remodelling of irrigation to increase water allowances, the study revealed that at MSP & CCADP sites irrigation supplies were remodelled to increase the water allowances, however, no remodelling was done at FDP and MKDP study sites.

iii) Watercourse improvement can appreciably help to abate the increased irrigation demand issues of drainage areas. The study indicated that at MSP, FDP, CCADP and MKDP sites 43%, 9%, 20% & 50% respondents respectively expressed that their watercourses had not been improved. If those watercourses are also improved, then the beneficial effects of drainage systems can further be enhanced in those areas.

iv) The study indicated that 79%, 33% & 100% respondents at MSP, FDP & CCADP sites respectively, expressed that the groundwater quality was improved from *hazardous* to *usable* class due to drainage activity. However, 21%, 50% & 100% of the respondents at MSP, FDP & MKDP sites respectively, expressed that the groundwater quality was *marginal*, whereas, 17% at FDP expressed as *hazardous*. Although the groundwater quality was not fully improved, yet 44% farmers were mixing the groundwater with canal water for supplementing their irrigation, highlighting the shortage of irrigation supplies in those areas.

v) Farmers were using the poor quality *drainage effluent* for irrigation which was affecting in some ways the crops grown and the soil itself. This was mainly due to their lack of knowledge about the use of poor quality drainage effluent.

vi) With regards to drinking water quality improvement, 25% at FDP & MKDP and

60% respondents at CCADP expressed that there was no improvement, and salty water caused skin problems and other diseases in those areas.

vii) Farmers' willingness regarding salt land revegetation and/or fishponds programme revealed that at MSP, FDP, CCADP and MKDP study sites 71%, 92%, 20% and 75% respondents, respectively expressed their willingness to grow agro-forestry at their salt lands with the condition if they were provided with nursery plants and some financial assistance. Whereas, 50% (MSP), 100% (FDP), 10% (CCADP) and 75% (MKDP) respondents showed their willingness for fish culture programme with the same conditions of free training and financial assistance.

viii) Reduction in waterlogging due to drainage activity, leads to other new problems which are interlinked to each other, and hence need to be addressed at the same time. For instance, reduction in waterlogging turned into salinity which requires extra irrigation water. Lack of coordination among related departments such as WAPDA, Agriculture Extension & Irrigation Department, and poor agricultural/technical advice to farmers under these circumstances means reduced/slow benefits from the drainage facilities.

5.2 Recommendations

- Post-project irrigation requirements should be reviewed carefully on priority basis to facilitate adequate irrigation supplies in drainage areas.
- Watercourse improvement can appreciably help to abate the increased irrigation demand issues of drainage areas. Therefore, the unimproved watercourses should be improved so that the benefits of drainage systems can further be enhanced.
- In both those areas where waterlogging is a problem, and where it has been reduced, it is important that beneficiaries be given relevant technical/agricultural advice about suitable crops to grow under prevailing conditions. Similarly, motivation can also be given for agro-forestry and /or fish pond programmes for their salt lands. This information can effectively be imparted to farmers through the agriculture extension service.
- In order to harvest the maximum benefits from subsurface drainage projects, the coordination among various departments such as WAPDA, Agriculture Extension Department and the Irrigation & Power Department etc. should be strengthened in those areas. Also the credit facilities for farmers should be improved.
- There should be government water supply schemes to avoid major health problems in drainage areas.

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MODELING OF LEAK DETECTION SYSTEM FOR HIGH PRESSURE TRANSMISSION SYSTEM OF NATURAL GAS

By

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ABSTRACT

Gas Industry can be considered as one of the most important industries in the economy of any country. Safe Transportation of Gas is thus considered to be vital because interruption of Supply of Gas to consumers not only causes domestic problems but also loss of revenue to country [1]. Now most of power generation Sector has switched over their system to Natural Gas. So, interruption of supply to this sector can cause a lot of problems. This paper has provided assessment of technology approach and formulated this approach for Leak Detection Model in High Pressure Transmission system for current and future operations, which will improve the efficiency of any transmission company to a great extent. This model can be extremely helpful in conditions of Rupture Emergencies or Leakage because of corrosive conditions of Pipeline to manage the situation of resources in pipeline network [2]. Any exceptional readings or messages should alert the user to the fact that something is wrong with the system. Such a system helps a lot in the safe and efficient management of pipeline network. The data and information provided by the Leak Detection System applications will allow for efficient and safe pipeline operation maximising profitability over the pipeline's service lifetime

1) INTRODUCTION

Rupture attacks on transmission pipeline system have become a great problem for different Oil and Gas companies [3]. Moreover, corrosive environment of pipelines and accidental problems have increased the need of leak detection system to a great extent. These companies are facing the problem of lack of some modern system for leak detection and use Gas parameters for Survival Time Analysis, Look Ahead Tasks, Leakage detection and any other rupture emergency. This issue results in a lot of problems during emergency handling of rupture of transmission pipeline systems [4].

2) SOLUTION-LEAK DETECTION MODEL

The core of Leak Detection Model is a hydraulic simulation model of the physical pipeline based on critical inputs: Remotely monitored flows, pressures, temperatures, density etc. These measurements are termed boundary conditions.

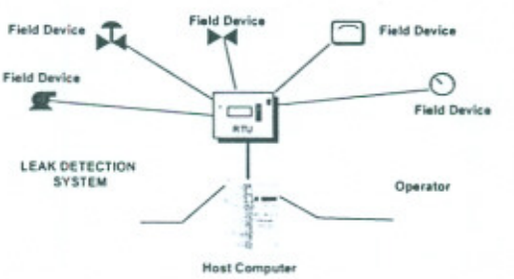


Figure 1 - Basic Leak Detection System [1]

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2.1 Hardware

It is separate from Remote Monitoring System. The Leak Detection Model Runs On 2.0 GHz Pentium IV Computers. The hardware specifications of the hardware are;

(a) Pentium IV, 2.4 GHz Processor
(b) 1 Gb RAM
(c) CD-RW and DVD Drives
(d) Ethernet Card
(e) 17" Colour Monitor
(f) Keyboard/Mouse

System Functionality is provided by: -

2.2 Software

(a) Real-time models-flow/pressure/temperature
(b) Leak detection
(c) Predictive etc

The Leak Detection Model consists of both Hardware and Software to Provide a Leak Detection and Pipeline Modeling System with inbuilt verification procedures. [5,6]

2.2.1 Specifications Of Software

The necessary system software is as follows:

- Windows XP Professional Operating System
- Leak Detection Model control system
  - (a) The console for the system computer is a 17" colour monitor, mouse and a keyboard.
  - (b) Modeling Software

The Utility programs are as follows:

- Database Manager
- Task Control Program
- Alphanumeric Terminal Handler

2.3 Real Time Modelling Parameters

- Models physical pipeline
- Two basic models - PQ, QP
- Use metering for pressure, flow, temperature, density at the inlets and outlets (the boundaries of the pipeline)

2.3.1 Real Time Modelling: Physical

2.3.1.1 Modelling of Pipes and Equipment

I. PIPE

- Pipeline segment
- Nodes
- Inflow/outflow

ii. **JOINT**

- Location of discontinuity (flow/pressure)
- Inlet / outlet
- Product sharing / mixing
- Multiple junctions
- Other equipment

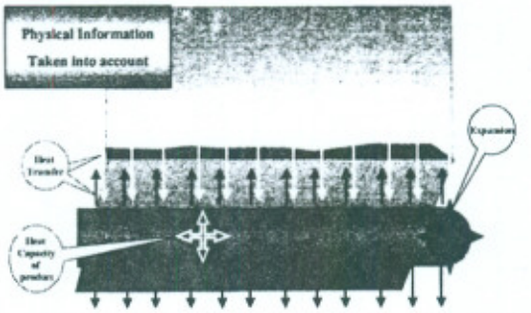


Figure 2 - Real Time Modelling: Physical. [7]

2.3.2.1 REAL TIME MODELLING: MATHEMATICAL

- Boundary Conditions

  (a) Flow
  (b) Pressure
  (c) Temperature
  (d) Density

- Method of Characteristics
- Product Tracking

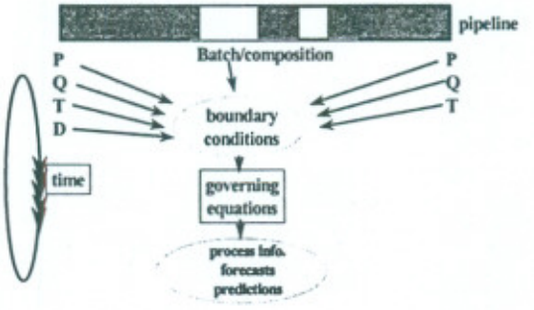


Figure 3 - Real Time Modelling: Transient.

3) PRESSURE/FLOW MODELS –PIPE, JOINT

The dynamic pipeline pressure/flow models generally consist of two parts:

- **PIPE:** modeling of pipeline
- **JOINT:** modeling of end points and inlet/outlet points along the pipeline

The dynamic pipeline pressure/flow models are denominated QP and PQ due to the boundary conditions that are used to drive the model. These P and Q show Pressure and Flow, respectively.

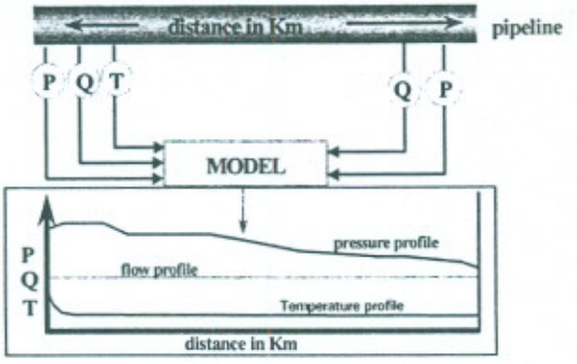


Figure 4 - Real Time Modeling: Profiles

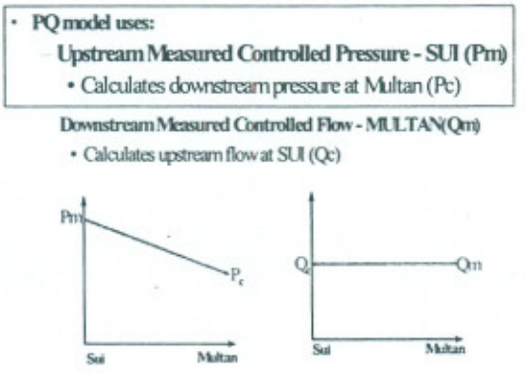


Figure 5 - The PQ Model.

- **PQ model** uses pressure upstream and flow downstream
- **QP model** uses flow upstream and pressure downstream

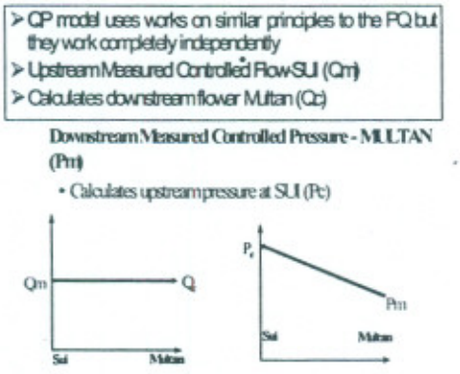


Figure 6 - The QP Model.

During periods with loss of data as boundary conditions, the system automatically emulates the invalid data if it is possible, e.g., by using other combinations of data, specified in the configuration. [8]

In case a boundary condition is invalid (neither measured nor emulated), the pressure/flow model using the boundary condition will stop updating. If the boundary condition is partly valid for modeling, the pressure/flow model continues updating, but with a reduced accuracy (higher status). The governing equations – conservation of mass and momentum – are solved numerically in a fixed x-grid along the pipeline by the method of characteristics. In the solution, account is taken for variations in:

- Friction factor
- Pipe expandability

4) THEORY OF PQ AND OP MODELS

- Leak detection Model uses the PQ and QP models together with other information, such as temperature, density etc
- Output is a set of calculated profiles for pressure and flow used for leak detection
- From these profiles, we have calculated flow and pressure at boundary points of the pipeline. [1]

5) TEMPERATURE MODEL – TEMP

In case a boundary condition is invalid, the corresponding temperature model will stop updating. If the boundary condition is partly valid for modeling, the temperature model continues updating, but with a reduced accuracy (higher status).

The governing equation – conservation of energy – is solved numerically in each of the calculation points along the pipelines by the method of characteristics. [1]

Ground temperature is represented by a SINE curve where amplitude and time offset is configurable. A real time temperature model is implemented in Leak Detection Model.

6) PRINCIPLES OF LEAK DETECTION MODEL

- Based on real-time models
- Models driven by pipeline boundary measurements:
- Calculated values (taken from profiles) for P, Q compared to corresponding measurements
- Checks on variations in pressure or flow
- Unexpected variations indicate leaks
- Model-produced profiles of pressure, flow and temperature account for variations due to operation
- Leaks cause unexpected variations and a well defined pattern of deviation between calculated and measured values develop These expected variations cause no deviation between calculated and measured values (*responses*) Leaks cause changes in pressures and flows along the pipeline

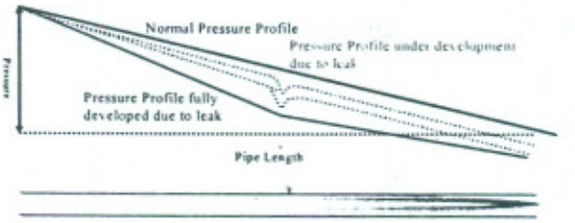


Figure 7 - Leak Detection Model - Unexpected Pressure. [7]

- These changes develop over a period which may be compared to the period the pipeline takes to reach steady state conditions after, for example, a change of inflow
- After a period of transient development of the leak, a steady state response is reached determined by the pipeline controls, which determine the flow distribution.

7) CONCLUSION

The main asset that a pipeline has is its ability to move gas from one location to another safely without any leak problem. The Leak Detection Application uses the accuracy and high level of resolution in the Real-time Model to detect small changes in pipeline measurements resulting from a leak. Leak detection is provided by statistical analysis of the discrepancies (*responses*) between measured and calculated values. Leak Detection Model will raise an alarm if it has detected a leak in the pipeline system. This alarm is passed to Remote Monitoring System. Alarms should not be ignored - evaluation of the problem and acquisition of supplementary data is important. The Real-time Model provides a raw indication to distinguish between leaks and operational variations.

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DEPOSITION OF SILICON CARBIDE IN CVD REACTOR

By

*Sajjad Amin Hassan

ABSTRACT

The unique properties of silicon carbide (SiC) make it a promising material to be used in micro-electronics and number of other applications. Some of the important properties that SiC possesses are large band gap, resistance to oxidation at high temperatures, high corrosion resistance and good mechanical behavior. Silicon carbide is being used for coating of nuclear fuel particles, high voltage switches, ceramic matrix composites for engines and space shuttles and high power electronics [3, 6, 8].

1) HISTORY

SiC was first discovered in 1824 by Jons Berzehus. The growth of polycrystalline crystals of SiC in a melting furnace was first developed by Eugene Acheson in 1885. This process continued till 1955[3]. In 1955, a sublimation growth process was developed by J.A. Lely at Philips research labs. at Einhoven [4]. In 1978, a physical vapor transport process (PVT) was introduced by Turov. The Lely process was then later on modified by a group of researchers working at North Carolina State University, who introduced a seeded sublimation growth process [5]. This group then formed a small company called Caree Research that then became the main supplier of SiC wafers later in United States.

2) CURRENT PROCESSES

Currently, the most common processes that are used to deposit SiC films are;

a) Chemical Vapor Deposition
b) Lely Growth Process
c) Seeded Sublimation Growth Process

a) Chemical Vapor Deposition

This as the most commonly used process to deposit thin SiC films. In this process, a mixture of different gases are introduced into a chamber. Both hot wall and cold wall reactor chambers are used for this purpose. The higher the temperature, the higher will be the probability of epitaxial growth. At high temperatures, we get pure crystals at the same time the etch rate from the surface is increased. The growth rate therefore is determined by desorption of reactants, the etch rate and diffusion dominated mass transport of source molecules. The growth rates obtained by CVD processes operating at low temperatures are really low and can be increased by increasing the temperature but this process called HTCVD is not commercially available.

b) Lely Growth Process

In a CVD process, the growth is driven by initial composition of gases but in this process, the temperature gradients within the system directly affect growth rate. The partial pressure of SiC is high where temperature is high, this leads to a pressure gradient which results in the mass transport from the hot parts of the crucible to the cooler parts of crucible [5]. In this process, porous graphite holds a source and the temperature is minimum at the origin. Therefore, the gases travel towards the origin creating a pressure difference and hence mass transport. The crystals grown by this process are random in size and large which is a drawback of this process.

*PE : Member AIChE

c) Seeded Sublimation Growth Process

This is a modified form of Lely process and seed crystal is used in this process which results in a more controlled nucleation. In this process, the SiC at source sublimes at high temperature and low pressure. The temperature is around 1800-2600°C. The resulting gases travel to cooler seed crystal through natural transport processes and super saturation takes place.

3) METHODS OF MODELING, EXPERIMENTS AND DATA ANALYSIS

There are many different models available that represent different processes. For this project, I am going to talk about the Chemical Vapor Deposition of silicon carbide films using CVD reactors. For this section, different models are discussed specific to mass transfer in detail. However, heat transfer, kinetics and flow are not discussed in detail for this project.

In 1984, Micheal E. Coltrin and J. Kee developed a general and simple one-dimensional model for the deposition of Silicon in a CVD reactor [1]. The basic assumption used in this model was Navier-Stokes equation that can be reduced to a system of a parabolic equations and the diffusion in axial direction can be neglected. The mass balance equation used is given as;

$$\rho u \frac{\gamma Y_k}{\gamma x} = \omega W_k - \frac{\rho u}{M} \frac{\gamma}{\gamma \xi} (y \rho Y_k V_{Ky}) \qquad \text{Eq. (1)}$$

In this model, two different sets of boundary conditions for two different geometries are specified for U, T, y and Yk. The transport equations were then solved using a computer code called DASSL and the calculated results were compared with the experimental results. The model predicts that the gas velocity has an important effect on gas phase concentrations and with the increase in the gas velocities, the residence time in the hot reactor region is decreased and hence the reaction rate is decreased resulting the deposition rate to be controlled by diffusion. This model later on became basis for most of the future models that deal with the deposition of SiC.

This model was modified in 1986 by same people working at Sandia National Laboratories in California and New Mexico [2]. The most important modification they made in their previous model was the inclusion of a thermal diffusion term that results due to temperature gradient in the reactor. Due to this thermal diffusion term, the concentration terms were expected to change. An important thing that the authors claimed was the application of this model to low pressure chemical vapor deposition process (LPCVD). The mass transfer equation used is as follows [2].

$$\rho u \frac{\gamma Y_k}{\gamma x} - \rho u \frac{\xi}{M} \frac{dM}{dx} \frac{\gamma Y_k}{\gamma \xi} = \omega W_k - \rho u \frac{\gamma}{M} \frac{}{\gamma \xi} (y \rho Y_k V_{Ky}) \quad (k=1,\ldots\ldots k-1) \qquad \text{Eq. (2)}$$

A multi component diffusion system was considered. In their last model, an approximate Stefan-Maxwell formulation was used. A FORTRAN package was used to solve the transport equations. The diffusion velocity using mixture-averaged approximation was given by; [2].

$$V_{Ky} = \frac{y \rho \mu}{X_k W M} \sum_{J \neq K}^{k} W_J D_{kJ} \frac{\gamma x}{\gamma \xi} - \frac{D^T_k}{\rho Y_k} \frac{y \rho \mu}{TM} \frac{\gamma T}{\gamma \xi} \qquad \text{Eq. (3)}$$

The diffusion velocity in this equation solely depends on the concentration gradient. Sample calculations were performed at different conditions and involve 27- complex chemical reactions. It was concluded that deposition is diffusion controlled.

Michael E. Coltrin, G. H. Evans and J. Kee then developed a general model for a rotating disk reactor (RDR) in 1989 which was then modified for Silicon Carbide deposition using a RDR by Mark Allendrof and J. Kee working at the Sandia National laboratories at Livermore in California [8]. In a rotating disk reactor, the heated substrate spins at about 1000 rpm and the temperature distribution remains the same all over the substrate [8]. The gases used for SiC deposition were SiH4 and C3H8. Silicon carbide was deposited epitaxially on a pre-existing SiC wafer. Multi component diffusion was used and the diffusion velocity was expressed as follows [8].

$$V_K = \frac{1}{X_k M} \sum_{J=1}^{K_g} M_J D_{Kj} \frac{dX_j}{dx} - D^T{}_k \frac{1}{\rho Y_K T} \frac{dT}{dX} \qquad \text{Eq. (4)}$$

For the boundary conditions, it was assumed that the mass flux for each species is balanced by the creation or depletion rate of that species due to surface chemical reaction [8]. The inlet conditions were used as the boundary conditions for the space far from the disk and the radial and circumferential velocities were assumed to be zero. Finite differential method was used to solve the transport equations. The experiments were carried out in a steady state CVD reactor and Si/C=I was mixed with Hz gas at atmospheric pressure. The temperature was kept between 1600-1800K. The kinetic study was performed for 83 complex reactions. Concentration profiles as a function of height above the disk were predicted in the following figure.

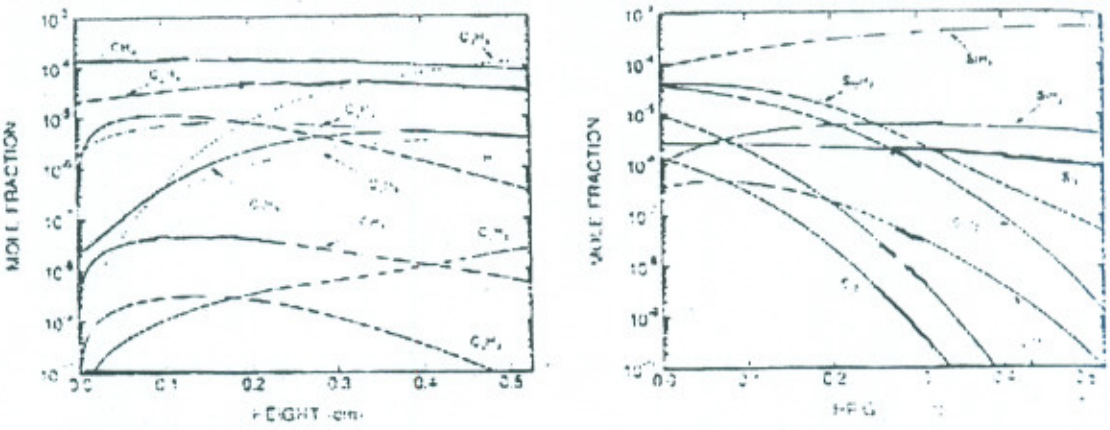


Figure 1. Height vs. mole Fraction [8]

From the figures it was predicted that most of the decomposition takes place near the disk and the mole fraction of carbon species at the surface is really low, showing that they are consumed and the process to be transport limited at the surface. The hydrocarbon reactant propane is more than 96% decomposed above 2mm of disk. Two carbon species C2H4 and C2H2 showed different behavior than all other species as their concentration was two-orders of magnitude lower than all other carbon components. This model was claimed to be the first model for the deposition of SiC using a RDR. The authors state that these results cannot be compared to the other reactors due to the difference in the geometries [8]. It is difficult to tell the validity of the model without comparing it to other models.

Hitoshi Habuka, Takatoshi Nagoya, Masanori Mayusumi, Masatake Katayama, Manabu Shimada, Kikuo Okuyama described the epitaxial growth of SiC under a SiHCl3-H2 gas system in a hot wall reactor at atmospheric pressure. The study was carried out at Hiroshima University and Isobe R&D center in Japan in 1996 [9]. The model was developed for the industrial scale production of SiC. Both mass transport and the surface reactions were taken into account in order to discuss the epitaxial growth rate quantitatively. The substrate was heated at 1073, 1223 and 1398 K by using infrared furnace in a horizontal reactor with quartz wall at atmospheric pressure. An important consideration made in this model was cooling the furnace walls with cold water so that the radiation effect could be neglected. The basic transport equations for mass, momentum and energy were solved simultaneously evaluate the film growth [9].

$$\frac{\partial}{\partial x}(\rho u \omega_i) + \frac{\partial}{\partial y}(\rho v \omega_i) = \frac{\partial}{\partial x}\left(\rho D_i \frac{\partial \omega_i}{\partial x} + D_i^T \frac{\partial \ln T}{\partial x}\right) - \frac{\partial}{\partial y}\left(\rho D_i \frac{\partial \omega_i}{\partial y} - D_i^T \frac{\partial \ln T}{\partial y}\right). \quad \text{Eq. (5)}$$

In this model binary diffusion was used in order to solve the binary diffusion coefficient. The boundary conditions used to solve the transport equations are given by the following equation [9].

$$R_i = j_C + j_T = -\rho D_i \frac{\partial \omega_i}{\partial y} - D_i^T \frac{\partial \ln T}{\partial y} \quad \text{Eq. (6)}$$

The assumption that mass transport is balanced by the surface reaction is used here [9]. A mesh of 78*82 grid points was created to solve the transport equation with the help of CFD package called FLUENT. According to the authors SiC12 was chemisorbed on the surface and was the dominant specie for the epitaxial growth of SiC. Following figure describes the whole mechanism of the growth of SiC.

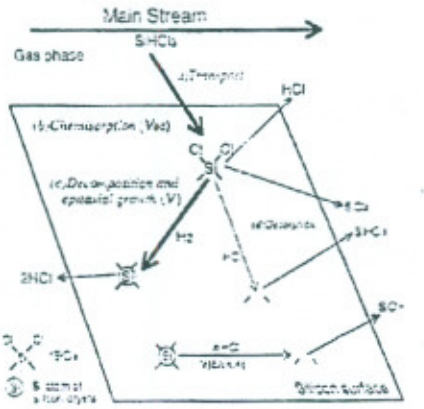


Figure 2. Basic mechanism of SiC deposition [9]

Different simulations were generated in order to analyze the measured and calculated data. The concentration of SiHcl3 was much lower at the surface as compared to the inlet of the reactor because of the chemical reaction, diffusion and thermal diffusion into the substrate. It was noticed that by decreasing the temperature the difference between the concentrations of SiHCl3 become much lower at two points because of depressing of chemical reaction [9]. It was predicated that the growth of SiC depends on the chemical reaction near the surface

and mass transport in the reactor. This might be due to the chemisorptions of SiCl3. Both the calculated and measured results agree well. The film thickness was measured by using interference fringe in the Fourier transform infrared spectra [9].

W. Ji, P.M. Lofgren, C.Hallin, C-Y. Gu and G.Zhou have developed a model of SiC epitaxial growth in a hot wall reactor working at Linkoping University in Sweden [10]. The following equations relating to mass transport has been used. They used binary diffusion co-efficient in place of multi-component diffusion in order to simply the calculations.

$$-\nabla \cdot (\rho v \omega_i) - \nabla \cdot j_i^c + j_i^l + M_i \sum_{r=1}^{R} \nu_{ir} (R_r^g - R_r^s) = 0 \qquad \text{Eq. (7)}$$

The mechanism is modeled for 81 complex reactions. Experiments were carried out in a horizontal hot-wall reactor with a SiC coated substrate and a RF coil is used to heat the suspector. Silane and propane were used along with hydrogen gas as a carrier gas between 1873 to l973 K and 50-550 mbar [10]. The predicted results are then compared with the experimental results but no method about the solution of mathematical model has been discussed in this article. Furthermore, it is concluded that the growth rate limitation is in error due to incorrect or limited reaction mechanism [10].

The same group of researchers developed a computational for SiC deposition in a hot wall reactor based on their above work. This is the most current model available for this technology. A mathematical model was developed with simulations on flow, heat and mass transport. A tapered reactor with a rectangular cross-section was considered in order to develop a 3-D model. They used binary diffusion co-efficients in place of multi- component diffusion in order to simply the calculations. The steady state mass transport equation used here is same i.e. eq (7) as one used in their previous work [11] but the equation for the diffusion velocity they got here is different from their previous work.

$$V_i = -\rho D_{i,m} \nabla \omega_i - \frac{D_i^T}{\rho \omega_i} \frac{\nabla T}{T} \quad (k = 1, \ldots, K_g) \qquad \text{Eq. (8)}$$

Like all other models discussed previously, here the authors have made the same assumption for the boundary condition i.e., the diffusive mass flux of gas phase is balanced by the production of gas phase species by the surface reactions. The authors have used the chemical model developed by Allendrof and Kee [8] as a basis. It is assumed here that when convection dominates in the main flow direction, diffusion mass flux of the species in that direction may be neglected [11]. This assumption is made to simplify the computer algorithm and verified later in the paper. The first order differential equation of transport is solved using a computer code ISODE developed by Hindmarsh [II]-

In order to verify the negligible effect of axial diffusion on the deposition rate the axial diffusion was first included in the model as a source term and calculated using the gas mass fraction from the preceding simulation and set to be zero in the first simulation. By predicting growth rates at different irritation steps, it was concluded that the axial diffusion has minor influence and can be neglected [11].
It was found from their previous model [10] that C2H2 and C2H4 are the most important carbon contributors and Si and SiH2 are most important silicon contributors. In the present work following simulations show the results for these species.

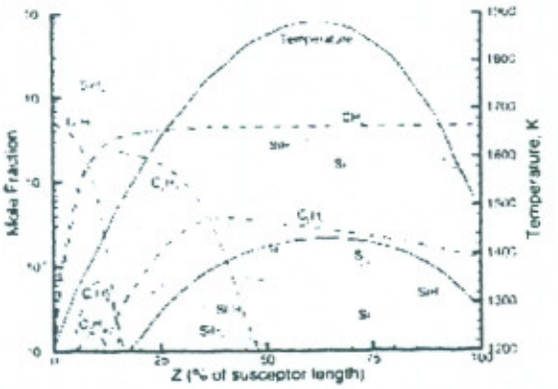


Figure 3 - Susceptor length vs. mole fraction [11]

It can be predicted from the simulations that all four species have zero concentration at the inlet and they are produces after the decomposition occurs. From the above figures it is clear that silicon contributors have higher concentration than the carbon species and the deposition is carbon limited. The following figures show the plot of growth rate vs. the C/Si.

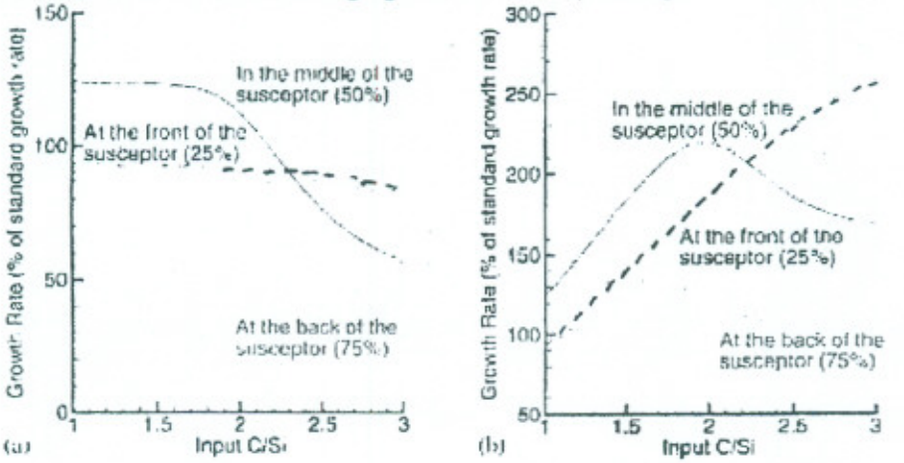


Figure 4 Growth Rate vs C/Si [II]

Dependence of the growth rate on input C/Si ratio. In the left plot, the inlet standard flux of C_5H_8 was kept constant at 2 ml/min, with the volume flux of SiH_4 changed. While in the right plot, the inlet standard volume flux of SiH_4 was kept constant at 6 ml/min, with the volume flux of C_3H_8 changed (1873 K. 300 m bar).

At C/Si == 1, the concentration boundary layer for the most important carbon species dominates which shows that the process is carbon mass transport limited.
The important thing in this paper is that the simulations show plots for both measured as well as predicted results. At low pressures the both experimental and predicated data for growth rate agrees well. This model is a very good modification of their previous work and answers all unanswered questions like why axial diffusion was neglected, what is the limiting step for deposition etc. from their previous work.

4) FUTURE RESEARCH

As the size of semiconductor devices is decreasing day-by-day new models and experiments are required to grow silicon carbide. In order to grow pure silicon carbide crystals high temperature conditions have to be used which are above 1873 K [8]. All the models described in this article do not apply at high temperatures. At high temperatures we get pure crystals but at the same time the etch rate from the surface is increased. The growth rate therefore become dependent on the desorption of the species from the surface.

This is one area to look for process engineers in terms of optimization. Thermal environment should be discussed further form the view-point of productivity improvement of silicon epitaxial wafer especially with a large size wafers. Therefore, the industrial possibility of a multi-wafer reactor should be studied further in order to design a future epitaxial reactor [12]. There are also other areas to be addressed in future like to lower defects, better doping uniformity and surface morphology.

5) CONCLUSIONS

The deposition of SiC in a CVD reactor is discussed in this paper. Different models are presented in a historical order with respect to mass transfer. All the above models discussed here are quite interesting. They all use different approaches to address the same topic. All of them are valid under different conditions. The models were discussed briefly and this discussion can be extended a lot with the amount of material available on this technology.

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CHEMICAL ANALYSIS FOR WASTE MINIMIZATION IN PAINT INDUSTRIES

By

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ABSTRACT

The chemical analysis of paint industries waste was carried out and it was observed that the main emission sources are the heating of raw materials and lacquer. Also, the waste from other applications and production contains high concentration of heavy metals, Volatile Organic Compounds (VOCs), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS) with notable acidity and alkalinity. Based on the analysis it was observed that the major losses in production could be minimized. Furthermore, the toxic effects of the waste material can be minimized. In this reference, measures to minimize production losses should be adopted along with proper management. These laboratory results also lead to the areas of emissions and waste production during manufacturing process. Solutions have been proposed for process development and integrated waste minimization.

1) INTRODUCTION

The toxic nature of chemicals in solvent-based paints may cause toxicity because they contain heavy metals like lead, chromium, mercury and zinc etc. The waste disposal in the paint industry is from two sources, one from the paint manufacturing and the other from the application of paints like roller painting (decorative) or spray painting, applied in automotive and other paint industries for various purposes [6]. The normal practice in the paint industries for disposing the waste is to pass it into sewers, and/or dumping in the available site. Most often, land filling technique is adopted. Only primary treatment of wastewater or liquid, having waste fluids, suspended particles, is done [1]. The solid particles are settled and disposed of quickly. In some cases, incineration methods are also used.

The paint waste coming from different paint operations can effect the environment in different ways. The VOCs produced from manufacturing and application of paint is affecting the environment badly and also the human life besides paint industry site [11]. In addition, solvents, latex paint entering in the drainage system and sewer has harmful impacts on aquatic life. Other impacts include water contamination, fumes in air due to excessive volatile compounds in solvent-based paints.

2) PROCESS DESCRIPTION

The flow sheet of a typical paints formation plant is shown in Figure 1. These unit operations are shown in proper sequence, 500 different raw materials are blended and a variety of procedures are used for finished products. Since, the techniques of paint technology formulation are still largely empirical, some authorities believe the most important concept is that of pigment volume concentration (PVC) [8,9]. It is defined as:

$$PVC = \frac{\text{Volume of pigment in paint}}{\text{Vol. of pigment in paint + Vol. of nonvolatile vehicle constituent in paint}}$$

PVC largely controls such factors as gloss, reflectance, rheological properties, wash-ability and durability. The data were collected from a paint manufacturing factory in Sindh. The various operations needed to mix paints are completely physical.

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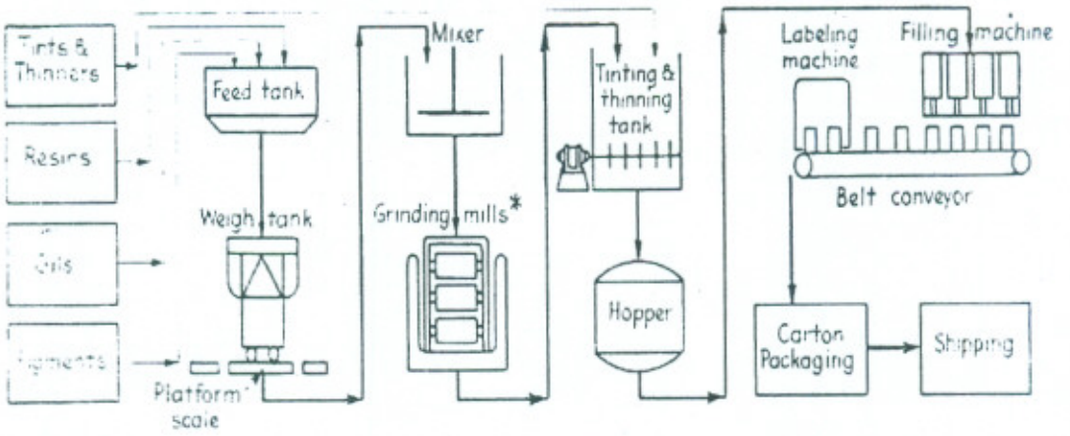


Figure 1 - Flow Sheet for the mixing of paint

3) EXPERIMENTAL WORK

The samples were collected for two consecutive days on various stages and tested under the standard procedure. The basic characteristics of the effluents are given below:

Liquids: The effluents from the manufacturing process are washed and conveyed to the sedimentation tank, which has two baffle walls and three compartments [4]. The objective of providing of sedimentation tank is first to pump out decanted effluents and secondly to retain settled sludge in the bottom of the tank. A submerged pump is installed in the tank to pump out effluents to the sewer running outside the premises. The solvent-based vessel washing effluents are collected in drums and subsequently taken out of the premises of the factory. This waste material is sold to motor garages and painters after solidification. The washing water based effluents from sedimentation tank having flow rate of 29000-30000 lit/day and vessel washing solvents flow rate of 25-30 lit/day to scrap contractors, were noted.

Air Emissions: The gaseous emission is based on power generator exhaust and excessive vaporization of solvents during production. Dust particles are generated when charging the powdered raw materials [3, 2, 4]. The laboratory results for gaseous emissions are given in Table 1.

Table 1
Laboratory Results for Gaseous Emissions

Location	Emission Source	No. of Stack	Particulate Matter, mg/l	Carbon as CO, mg/m^3	Temperature, °C
Resin	Heating of Raw Material	4	80-95	22.54	86
Container	Heating/Lacquer	8	80-95	22.54	50

Solid Waste: The solid waste generated from different process areas is collected in separate bins. When the bins are full; they are stored in junkyard for dumping/disposal. These include rejected containers, scrap drums and sludge [3]. The sludge mainly of water-based paint is taken out of the sedimentation tank after 2-2$^1/_2$ months and disposed of out of factory's may be fused and may be land filled after some time Table 2 shows the laboratory results of sedimentation constituents, Table 3 shows the constituents in solvent drum and Table 4 shows the laboratory results for paint industries sludge.

Table 2
Constituents of Sedimentation Tank

Parameters	*First Day Samples*	*Second Day Samples*
Temperature	36 °C	33 °C
pH at 25 °C	9.2	7.7
BOD	637 mg/l	250 mg/l
COD	1165 mg/l	600 mg/l
TSS	141 mg/l	655 mg/l
Settleable Matter	2.5 mg/l	2 mg/l
TDS	1299 mg/l	1679 mg/l
Oil & Grease	165 mg/l	342 mg/l
Phenolic Compounds	0.4 mg/l	0.2 mg/l
Chloride as Cl	262 mg/l	245 mg/l
MBAS	0.07 mg/l	0.05 mg/l
SO_4	140 mg/l	109 mg/l
NH_3	-	-
Nickel	-	-
Iron	-	-
Manganese	0.07 mg/l	0.8 mg/l
Sodium	200 mg/l	156 mg/l
Calcium	55.1 mg/l	69.9 mg/l

Table 3
Constituents of Solvent Drum

Parameters	*Results*	*NEQS Limits*
Appearance	Dark Brown	-
Water %	0.4	-
Resin (Solvent) %	100	-
TSS, mg/l	249	150
TDS, mg/l	19002	3500
Phenol	2.3	0.1
Mg, mg/l	-	-
Lead, mg/l	0.2	0.5
Oil & Grease, mg/l	18099	10

Table 4
Laboratory Results for Paint Industries Sludge

Parameters	*Results (wt%)*
Grease & Oil	0.7
Carbonate	0.2
Nickel	0.0007
Nitrogen	7
VSS	16
Iron	0.05
Manganese	0.004
Calcium	0.66

Table 5
Wastewater Characteristics

Section	*pH*	*Acidity*	*Alkalinity*
Hot Resin	8.3-11.7	-	25
Pre. Degrease	9.9-12.1	-	28-46
Main Degrease	9.9-12.1	-	28-46
Water resin-1	7-10	-	2
WaterResin-2	7-8.5	-	1
Activation	8.5-10	-	2-4
Phosphate	2.2-3.7	20-22	-
Water Resin-3	2.2-3.7	2	-
Water Resin-4	2.2-3.7	1	-

Table 6
Characteristics of wastewater after equalization of process wastewater

Parameters	*Values*
PH	4-6
BOD at 25 °C	650 mg/l
COD	1100 mg/l
Oil & Grease	50 mg/l
Zn	10 mg/l
Ni	10 mg/l
TSS	250 mg/l
PO_4	175 mg/l
Cr Total	1.5 mg/l
Pb	0.5 mg/l

The waste constituents of sedimentation tank and solvent drum show very high BOD, COD, VOC's, TDS, Na, Chlorides, SO_4 ions, toxic metals (Ni, Pb, Cr, etc.) and oils concentration. TDS from sedimentation and solvent drum were very high as compared to NEQS limits. The laboratory results of paint sludge samples collected from various areas of paint production indicate the valuable amount of heavy metals and gases. A wastewater sample of different areas shows high acidity and alkalinity that has direct impact on the environment, hence, an integrated waste management approach is required.

Therefore, proven, state-of-the-art techniques of chemical and bio-chemical analyses of wastes are needed for the regulatory, remediation and waste management purposes. Therefore, while dealing with non-degradable hazardous waste, the toxic concentration of waste is an important factor in their environmental management and minimization. The quality and choice of analyses is much more important than the number of analyses performed [9]. Considering all these aspects of chemical analyses, a sustainable environmental design.

4) PROPOSED WASTE MINIMIZATION TECHNIQUE

Paint films deposited on walls can interfere with the recycling of industrial waste. The use of decomposable cross-linking paints can eliminate this difficulty. Elimination of the decomposable cross-linking paint films my produce another kind of wastes, that is, a solution containing decomposed resins [7,4]. Cross-linking paint films are created by areaction between carbonyl group and a hydrzide group, which can easily decompose by dipping it in water, solvents, or acid. This may be performed in two steps: first dipping in aqueous solution containing (solvents and acids), and washing with solvents. The proposed process is shown in Figure 2. Decomposition of cross-linking bonds and the elution of the decomposed free cross linker take place in the first dipping process and the elimination of the decomposed resins takes place in second washing process [7]. The aqueous solution may be used for a long time without contamination by the decomposed resins. The decomposed resins can easily be recovered from the resin solution containing no other contamination.

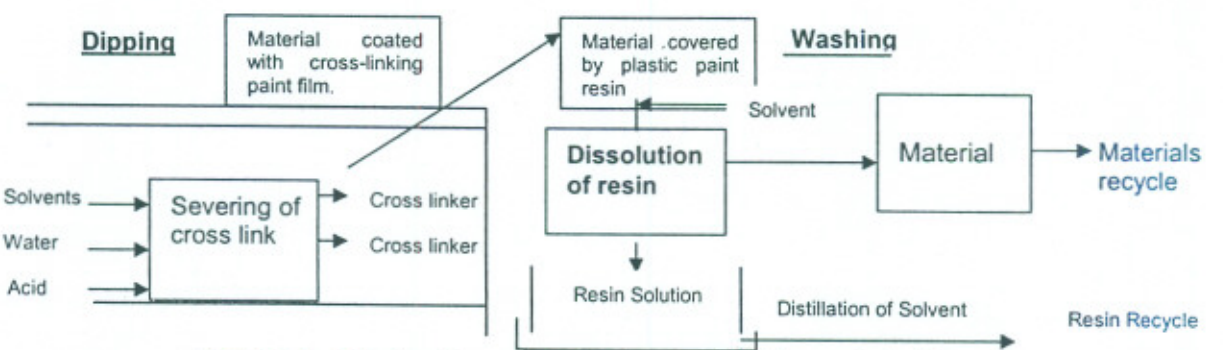


Figure 2 - Elimination process of cross-linking paints film

5) DISCUSSION

The excessive vaporization of solvents is a sources problem; Table 1 indicates the emission sources and their extents. As many samples of waste contain heavy metals, various petroleum products, including oils, oil sludges, tars, waxes, paint sludges other hydrocarbon materials and organic matrix [2]. The volatile materials of paints waste are commonly isolated by techniques that take advantage of their high vapor pressure. The general procedures, techniques and steps for solving the problem for waste management and waste minimization in paint industries during the manufacturing process have been discussed [6]. Waste in the solvent-based paints than in water-based paints will be more effective, therefore, more emphasize may be given to the waste of the solvent-based paints. The waste management is directly linked with the prevention of pollution, leading to an efficient and sustainable use of recourses. Though, toxicity of paint industries waste is a function of many factors, the matrix in which it is contained, circulation of exposure, the species exposed, manner of exposure, degree of exposure and time of exposure but till the most important; the chemical and bio-chemical properties. The wastewater of paint industries is less harmful but that should also be properly disposed of. The excessive production of volatile organic compound (VOCs) during application of paints can be reduced by using proper equipments and also by using high efficiency equipments (like electrostatic gum and afterburner) [8]. This excessive production of VOCs can also be reduced by proper exhaust of air near application site. Using latex (water based paint) wherever possible, careful handling, don't allow the paint wastage to go in sewerage, solvent-based paint must be treated carefully and NEQS limits [4] followed in disposal.

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1. Engr. Muzaffar Khan, (WAPDA Officer) died on 17th April, 2005.
2. Engr. Ch. Muhammad Daud (R) S. E. (Irrigation) died on 1st June, 2005.
3. Mrs. Farkhanda Aslam, Sister of Engr. Muhammad Naeem Chughtai, Member of Executive Council of Congress & C. E. (Building Deptt.) Punjab died on 17th June, 2005.

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- **Halving extreme poverty and hunger**
  Reduce by half the proportion of people who live on less than one dollar a day. Reduce by half the proportion of people who suffer from hunger.
- **Achieving universal primary education**
  Ensure that all boys and girls complete a full course of primary schooling.
- **Promoting gender equality**
  Eliminate the gender discrepancy in primary and secondary education by increasing opportunities for girls to attend school preferably by 2005 and at all level by 2015.
- **Reducing under-five mortality by two-thirds**
  Reduce by two-third the percentage of children who die before age five.
- **Reducing maternal mortality by three-quarters**
  Reduce by three-quarters the percentage of women who die in pregnancy and childbirth.
- **Reversing the spread of HIV/AIDS, malaria and TB**
  Halt and begin to reverse the spread of HIV/AIDS. Halt and begin to reverse the incidence of malaria and other major diseases.
- **Ensuring environmental sustainability**
  Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources. Sustainable development means reducing hunger and poverty in environmentally sound ways by meeting basic human needs, expanding economic opportunities, protecting and enhancing the environment, and promoting democratic participation. Reduce by half the proportion of people without sustainable access to safe drinking water. Achieve significant improvement in the lives of at least 100 million slum dwellers, by 2020.
- **Developing a global partnership for development, with targets for aid, trade and debt relief**
- Reform the trading system (i. e., the World Trade Organization) and the financial system (e. g., private capital flows and international financial institutions like the International Monetary Fund) so that poor countries can more easily sell their products to developed countries at fair prices and obtain the financial resources needed to create stable, growing economies that lift people out of poverty.
- Focus special attention on how to help the poorest countries mobilize the resources needed to reduce hunger and poverty and become self-reliant.
- Focus special attention on how landlocked and small island developing countries can promote economic development and poverty reduction.
- Make an all-out effort to resolve the problem of un-payable debt for the world's poorest countries.
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